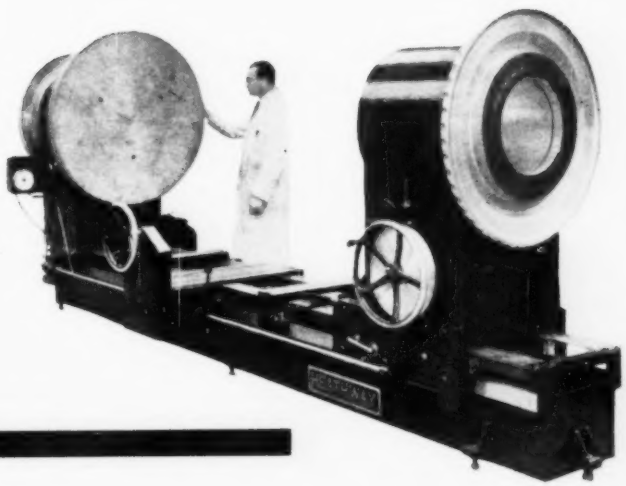
SUPPLEMENT: INDEX TO VOLUME 189

NATURE

A Weekly Journal of Science

Vol. 190, No. 4780 **SATURDAY, JUNE 10, 1961** **3s. 6d.**

Model Lathe supplied to Messrs. Quickfit & Quartz Limited—thought to be the largest Glass Lathe in existence. May we send you details of our standard range of Glass Working Lathes?



The Heathway Machinery Co. Ltd.

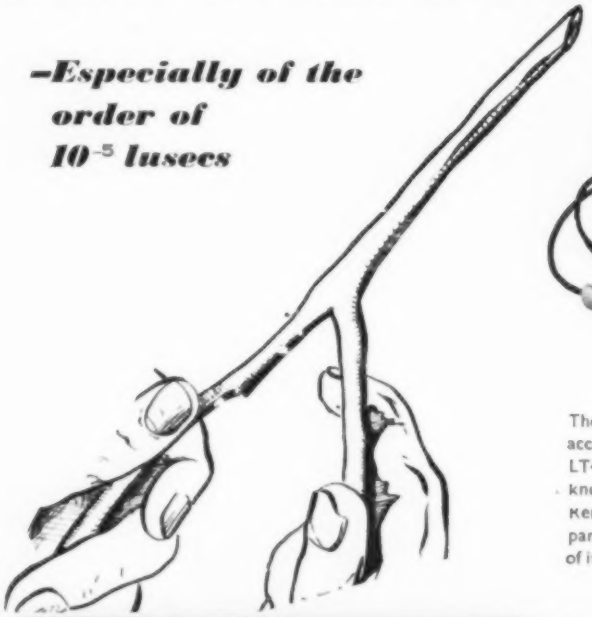
Uxbridge Road, Hillingdon, Middlesex. Uxbridge 36345/6.

OVERSEAS AGENTS:

FRANCE: Ets. L. Richoux, 22 Cité Trévise, Paris 9e.
HOLLAND: A. Bruyaux n.v., Postbus 4064, Amsterdam-Oost.
ITALY: Ets. L. Richoux, Milan.
SWITZERLAND / GERMANY: Ernst Keller & Co. A.G., Voltastrasse 102, Basle.
U.S.A.: The Bethlehem Apparatus Co., Hellertown, Pa.

HOW DO YOU LOCATE MINUTE VACUUM LEAKS?

—Especially of the order of 10^{-5} lusecs



The powers of the hazel twig may not be generally accepted, but the locating powers of the "SPEEDIVAC" LT4 PALLADIUM-BARRIER LEAK DETECTOR are widely known throughout the world of science.
Remarkably simple to operate, it has a sensitivity comparable with the mass-spectrometer—but at a fraction of its cost!

ASK FOR LEAFLET D.209/1

EDWARDS HIGH VACUUM LTD | MANOR ROYAL | CRAWLEY Crawley 1500 | SUSSEX | ENGLAND

TIME & MONEY

two important factors to consider when ordering research biochemicals

Nutritional Biochemicals Corporation

21010 Miles Avenue • Cleveland 28, Ohio

Of course quality of product is still the prime factor. And N.B.Co. is world famous for its complete stocks of the finest quality and purest biochemicals. But time and money are very important, too. Being able to deliver your biochemicals almost instantly and at economical prices have made N.B.Co. the world's number one Research Biochemicals House. Our stocks include Amino Acids • Peptides • Nucleoproteins, Purines, Pyrimidines • Vitamins • Enzymes-Crystalline, Purified • Growth Factors • Steroid Hormones • Miscellaneous Biochemicals.

Send for our free June, 1961 Catalog containing over 2600 items. Fill out coupon and mail today for your copy.

Name.....

Organization.....

City.....

State.....Zone.....(N)

. . . . built for a lifetime of constant use

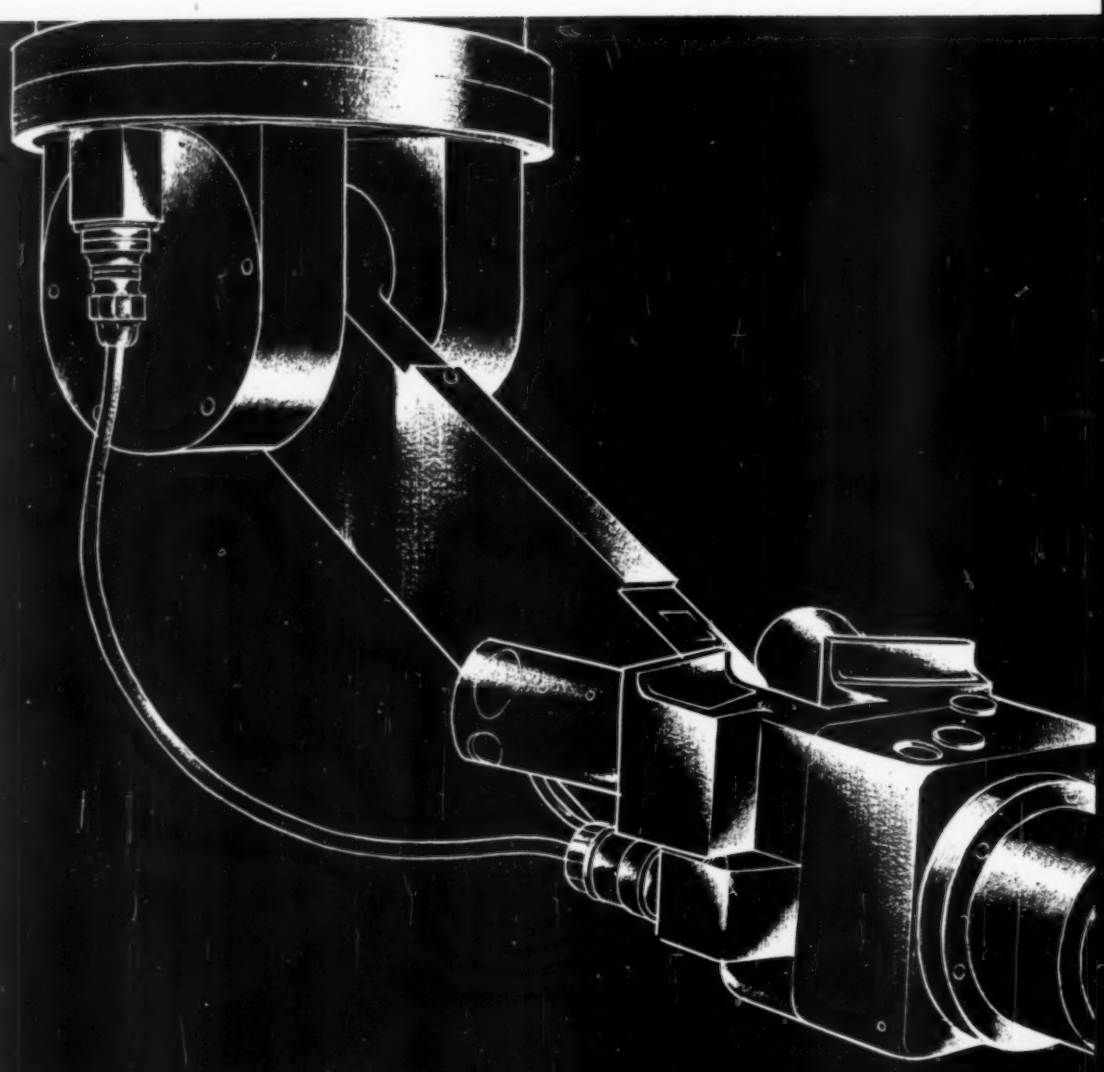
The 'SERVICE'

The "Service" is without doubt the finest student microscope today and has proved its high quality and serviceability in many school and university laboratories throughout the world. The simplicity of its design is allied with the highest standards of construction, resulting in a high quality instrument easy to work with and capable of giving a lifetime of satisfactory service in constant use. The comprehensive range of accessories, designed to make the "Service" suitable for more complex work is of equally high quality. See the Watson "Service" before you decide on your next microscope.

WATSON

A member of the PE INSTRUMENT GROUP

W. WATSON & SONS LTD · BARNET · HERTFORDSHIRE



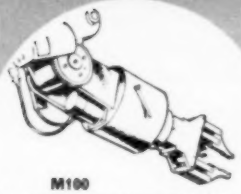
The outstanding N|E|L PLANS service

What makes the NEL Plans service so important? It includes complete and detailed preparation of layouts for any remote handling project. It enables you to build with confidence and to use the standard arms successfully even for highly specialised requirements. This cuts down installation costs so it pays to consult NEL early.

NEL

NE8 For lifting and handling R-A materials weighing up to 7lb. The equipment has power driven side-swing movements.

NE9 Highly manoeuvrable unit with maximum capacity of 100lb.

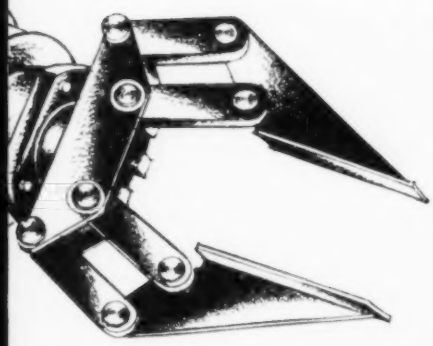


M100 Low cost system with full cell coverage and 200lb lift.

M150 Maximum manipulating facilities in minimum space, e.g. Alpha-Gamma handling in sealed dry box.

World's largest range of NUCLEAR HANDLING EQUIPMENT

THE M300



The M300 is a versatile 'all-purpose' unit from the wide NEL range. It is a standard mechanical arm with a lifting capacity from a few ounces up to 750lb. and its many special features include minimum headroom configurations where overhead clearance requirements are vital. Like all NEL equipment, the M300 is backed by outstanding service and the unique NEL plans service.

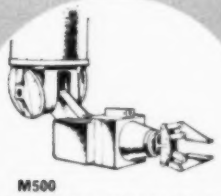
NUCLEAR EQUIPMENT LIMITED

Combining the knowledge, equipment and planning resources of two great nuclear handling companies: Savage and Parsons Limited of England and General Mills Inc., of the U.S.A.

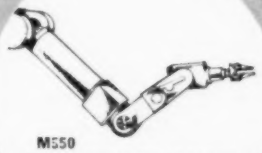
OTTERSPOOL WAY · WATFORD · HERTFORDSHIRE · WATFORD 26077

Technical literature on all these types is available from NEL.

Eight standard mechanical arms are provided in the range, with electric drives, variable speeds, finger-tip controls and automatic connections for power tools.



M500
Basically similar to M300. Handles up to 2,000lb. with fine control.



M550
Wide versatility of heavy load application, e.g. 100lb. cantilevered 18 ft.

M700
Heavyweight unit with rigid hook for lifting loads up to 5,000lb.

ISOTOPIC TRENDS

IRRADIATION WITH COBALT-60 —
A POWERFUL NEW INDUSTRIAL TECHNIQUE

The wide possibilities of gamma radiation in industry are only just beginning to be fully applied, for example in the sterilization of packaged products.

Cobalt-60 for such industrial processes is now available from the Radiochemical Centre in megacurie amounts. We shall be glad to provide specifications and information and to quote for the active sources necessary.

Comprehensive catalogues of Radioactive Sources and also of Radioactive Chemicals are available on application.

THE RADIOCHEMICAL CENTRE

AMERSHAM • BUCKINGHAMSHIRE • ENGLAND

TAS/RC 59

"ESCOPLASTIC"

VINYL PRODUCTS

FLEXIBLE AND RESISTANT TO MANY CHEMICALS

TUBING

CLEAR OR TRANSLUCENT, NON-PYROGENIC AND NON-TOXIC, FLEXIBLE, STERILIZABLE IN STEAM AT 120 C, IN SIZES FROM 0.5 mm. TO 40 mm. i.d.

BUNGS *COLOURED ORANGE*

55 STANDARD SIZES OR TO SPECIFICATION

PIPETTE TEATS

IN SEVEN COLOURS FOR IDENTIFICATION PURPOSES

No. 1 @ 60/- per gross
No. 2 @ 75/- per gross

TEST TUBE HOLDERS

8 STANDARD SIZES. *PRICE 16/- EACH*

Made in Great Britain by

ESCO (RUBBER) LTD.

Manufacturers of Rubber, Silicone Rubber and Plastic Products

34/36 SOMERFORD GROVE · LONDON · N.16

NEW VERSATILITY IN Liquid Scintillation Counting

With the Packard Tri-Carb® Spectrometer

Now you can count assortments of carbon-14 and tritium samples interchangeably without readjusting controls . . . perform double labeling at the true balance point for each isotope . . . or do both. In addition, the new Tri-Carb Spectrometer with its expander-amplifier circuitry can be used for dual-channel gamma counting merely by adding a well detector. This versatility is a Packard exclusive—made possible by two separate channels of pulse height analysis with individually variable amplifiers and four adjustable discriminator levels.

Other features are all-transistorized circuitry and convenient mounting of all controls at eye level above the freezer. Width of the instrument is reduced to a space-saving 3½ feet.

Three models in various combinations offer a total of nine liquid scintillation counting systems—refrigerated or non-refrigerated . . . for automatic or semi-automatic operation. From this selection you can readily meet the requirements of your budget and provide for present and future needs. You'll get the satisfaction and performance which only a Tri-Carb Spectrometer—with its world-wide reputation for accuracy and reliability—can provide. Call your Packard representative or write for Bulletin AD-1002.

INSTRUMENTS FOR RADIOACTIVITY MEASUREMENT AND CHROMATOGRAPHY

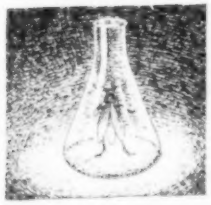
Packard

BRANCH OFFICES
CHICAGO • ALBUQUERQUE • ATLANTA • BOSTON
LOS ANGELES • NEW YORK • PHILADELPHIA • PITTSBURGH
SAN FRANCISCO • WASHINGTON, D.C. • ZURICH • PARIS

PACKARD INSTRUMENT COMPANY, INC.
LA GRANGE 60, ILLINOIS, U.S.A.

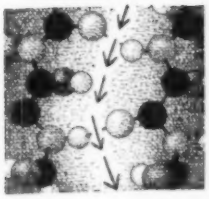
IT HAPPENED THIS MONTH...

a glance at yesterday in relation to today



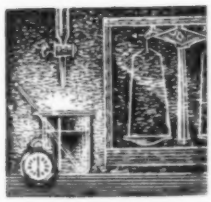
IN JUNE—(1301)—a paper read before the Royal Society describes some experiments and observations on "spontaneous light". Herring, mackerel, and other objects "that abound with spontaneous light in the latent state" do not emit such light when deprived of life. Contrary to what other authors have alleged, oxygen does not render this light more vivid than it is in atmospheric air. Azotic gas, on the other hand, is favorable to spontaneous light and helps preserve its emission and brilliancy, while hydrogen, carbonic acid gas, and sulphurated hydrogen gas act to extinguish it.[1]

More refined methods now permit us to make more reliable observations of bioluminescence. No longer is it necessary to depend on herring or mackerel. Schwarz BioResearch has recently made available a Firefly Kit for convenient classroom demonstration of bioluminescence and for ATP assay. The Schwarz Firefly Kit provides 500 mg. of dehydrated firefly tails, 250 mg. of crystalline disodium ATP, plus comprehensive instructions and background information.



IN JUNE—(1880)—R. H. Chittenden reviews recent work on the enzymatic breakdown of albumin. "... it is plain that by the first step in digestion the albumin molecule is resolved into its two parts [antialbumose and hemialbumose], the gastric juice then readily changing the hemialbumose into hemipeptone, while the anti-group appears less susceptible to the action of pepsin, only a small portion of this group being changed into antipeptone, while the larger part, under the influence of the dilute acid, appears to be converted into partially insoluble products: but on reaching the intestinal canal these insoluble bodies, under the influence of the alkaline solution of trypsin, pass readily into solution and are digested with formation of antipeptone, which is readily absorbed, while the hemipeptone is further changed into crystalline decomposition products."[2]

Today it is plain that many other proteolytic enzymes are involved in the digestion of albumin. Nevertheless, we still know almost nothing about the intermediate breakdown products. If you are studying the enzymic cleavage and synthesis of peptide bonds, you should have copies of two Schwarz catalogs: our regular catalog lists all the biologically important amino acids — plain and labeled with C^{14}, N^{15}, and S^{35}; a special catalog describes a long line of carboxy-amino acids, polyamino acids, polypeptides, and O^{18} — amino acid compounds produced by the Yeda Research and Development Company in Israel. Both catalogs are available upon request.



IN JUNE—(1949)—a group at Columbia publishes some new micromethods for the detection and determination of tissue hexoses. In 1946, Dische had described a new color reaction of hexoses with cysteine and other tissue constituents. Now, he and his associates have developed two modifications which promise to be of considerable value for the investigation of polysaccharides in animal tissues, body fluid, and bacteria and for measurement of blood galactose.[3]

If your micro, semi-micro, or macromethods involve either hexoses or sulfhydryls, you can probably obtain the compounds you need from Schwarz BioResearch. We produce a large number of biologically important sugars, sugar phosphates and sulfhydryl compounds — plain or labeled with S^{35} or C^{14}.

1. Hulme, N.: A continuation of the experiments and observations on the light which is spontaneously emitted from various bodies; with some experiments and observations in solar light, when imbibed by Canton's Phosphorus. Phil. Tr. Roy. Soc. London 97:303 (June 18) 1801. 2. Chittenden, R. H.: Report on progress in physiological chemistry. Am. Chem. J. 2:204 (June) 1880. 3. Dische, Z.; Shettles, L. B.; and Osnos, M.: New specific color reactions of hexoses and spectrophotometric micromethods for their determination. Arch. Biochem. 22:369 (June) 1949.

SCHWARZ BIORESEARCH, INC. • Dept. 6H • Mount Vernon, New York
BIOCHEMICALS • RADIOCHEMICALS • PHARMACEUTICALS *for research, for medicine, for industry*

Britain's finest value in Vacuum gauges

This inexpensive yet extremely reliable Leybold-Elliott range of vacuum gauges includes a model that will exactly meet *your* requirements. A unique feature of the PVE 41 control unit is that it is able to work with almost every available Ion gauge head. Other advantages include:

- Built-in out-gassing facilities
- Leak-detection facilities
- Protective circuits to protect both gauge head and stabilizer
- Suitable for standard G.P.O. rack mounting
- Five separately-switched ranges
- Stabilizing supply for the emission current in the ranges .2 to 20 m.a.

- Price only **£175** ex stock, Borehamwood

Write for full details of the Leybold-Elliott range of high vacuum gauges

LEYBOLD-ELLIOTT LTD

Manor Way Borehamwood Herts Tel: ELStree 3636

NATURE

No. 4780 SATURDAY, JUNE 10, 1961 Vol. 190

CONTENTS

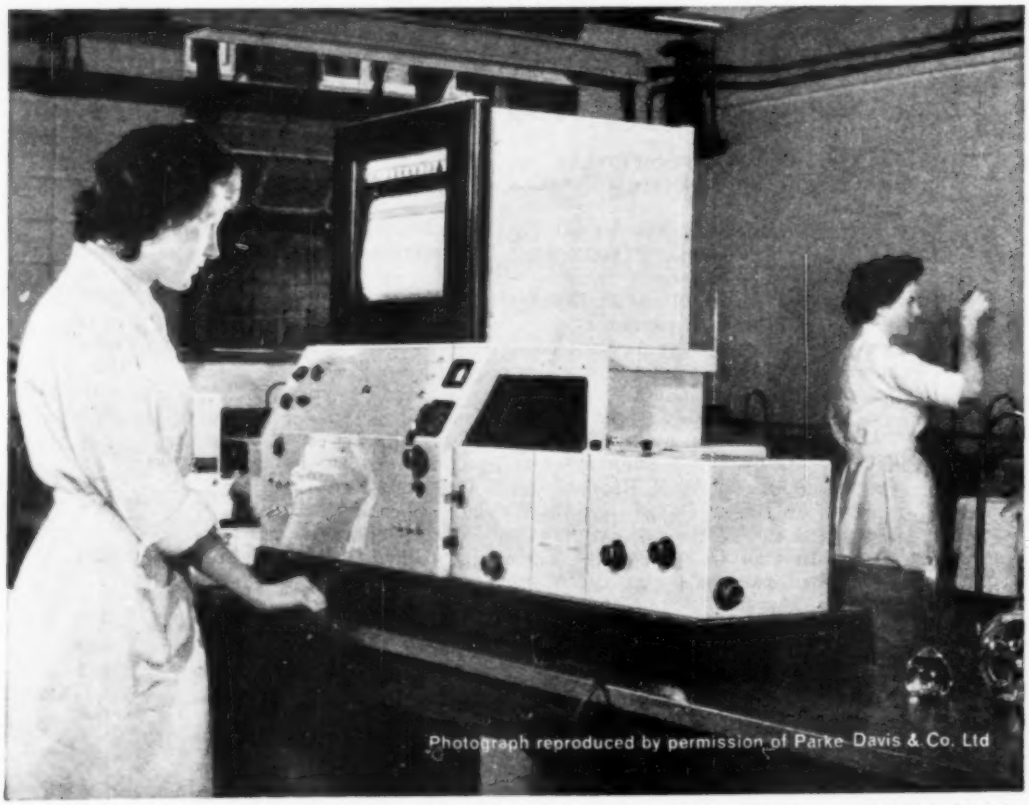
	Page
Co-operation in the Expansion of Higher Education	941
A Diversity of Theological Speculations. By The Very Rev. Dr. W. R. Matthews, K.C.V.O.	943
Advances in Analytical Chemistry. By Dr. D. T. Lewis	944
Fast-Neutron Handbook. By J. H. Montague	944
Mathematics for the Biologist. By J. F. Scott	945
Recent Advances in Entomology. By Harold Oldroyd	945
In Search of Race Relations. By Dr. Margaret Read	946
Centenary of the Massachusetts Institute of Technology. By Dr. James R. Killian, jun.	948
Recent Advances in the Biochemistry of Glycogen and Starch. By Dr. W. J. Whelan	954
Obituaries:	
Sir David Rivett, K.C.M.G., F.R.S. By Dr. I. W. Wark	958
Prof. K. Koshtoyants. By The Rt. Hon. Lord Adrian, O.M., F.R.S.	958
News and Views	959
University College of Swansea	964
Science and Industry—the Problem of Communication. By E. E. Williams	965
An International Andean Year. By Dr. V. Deulofeu	966
Solar Variations, Climatic Change and Related Geophysical Problems. By Prof. Gordon Manley	967
Experimental Taxonomy of Flowering Plants. By Prof. D. H. Valentine	968
The Indian Institute of Science	970
The Institute of Seaweed Research	970
Public Health Engineering	971
Chemotherapy of Malaria	971
Physical Anthropology of Australian Aborigines	972
Weather Forecasting by Numerical Methods. By Dr. A. W. Brewer	973
Precipitation of Sub-Micron Dust in Still Air by Cloud-Size Water Droplets. By Dr. M. M. Bhadani and N. G. T. Ludlow	974
Viscosity of Dusty Gases. By Dr. Wayne T. Sproull	976
Biochemical Changes accompanying Impaired Respiration in Staphylococci. By Prof. G. F. Gause, G. V. Kochetkova and G. B. Vladimirova	978
An Investigation of Closely Related Gamma-Myeloma Proteins and Normal Mouse Gamma-Globulin by Partial Enzymic Degradation and Starch-gel Electrophoresis. By Dr. Brigitte A. Askonas and Dr. J. L. Fahey	980
Respiratory Effects of Phosphorylation. By Prof. H. Lundegårdh	983
Colicine Factors as Fertility Factors in Bacteria. By H. Ozeki and Sheila Howarth; R. C. Clowes	986
Analysis of Irradiated *Drosophila* Populations for Meiotic Drive. By Prof. E. Novitski and G. D. Hanks	989
Chromosome Fragments and Mutation of the Incompatibility Gene. By Prof. D. Lewis, F.R.S.	990

(Continued overleaf)

UNICAM

This is the SP.700 Spectrophotometer. One of the most advanced analytical instruments of its kind. Precise—versatile—reliable—made for analysis through a spectral range of Ultraviolet, Visible and Near Infrared. The SP.700 records a detail of the composition of unknown mixtures—detects minute traces of the most elusive elements—completes in minutes a task which would take hours or weeks by other methods. Used by scientists in the great University and Industrial Laboratories of the world. Made by Unicam Instruments Ltd., Cambridge, England.

SP.700 Recording Spectrophotometer



UNICAM INSTRUMENTS LIMITED • CAMBRIDGE • ENGLAND

LETTERS TO THE EDITORS

Page

PHYSICS

A Notable Growth Spiral on Synthetic Diamond.—Prof. S. Tolansky, F.R.S. 992
An Upper Limit for the Resistivity of a Superconducting Film.—R. F. Broom 992
Flow of Visco-Elastic Liquids from Tubes.—J. Harris 993
Inelastic Scattering of Conduction Electrons in Dilute Silver–Manganese Alloys at Low Temperatures.—M. S. R. Chari 994
Breakdown Strength of Caesium Iodide.—R. Taagepera, R. S. Storey and Prof. K. G. McNeill 994

ASTROPHYSICS

Trajectories of Chromospheric Disk Surges.—J. M. Malville and G. E. Moreton 995

GEOLOGY and MINERALOGY

Origin of Ignimbrites.—F. J. Fitch 995
Skiddaw Slates proved in the Teesdale Inlier.—Dr. G. A. L. Johnson 996
Ekanite, a New Metamict Mineral from Ceylon.—B. W. Anderson, Dr. G. F. Claringbull, Dr. R. J. Davis and D. K. Hill 997

METALLURGY

Arc Initiation on Heated Metals by a Hydrogen Discharge.—J. T. Maskrey, R. A. Dugdale and R. C. McVickers 997

CHEMISTRY

Prevention by Cysteamine of Radical Formation in Bovine Serum Albumin by γ-Rays.—D. Libby, M. G. Ormerod, Prof. A. Charlesby and Dr. P. Alexander 998
Behaviour of Magnesium Impurity in Gallium Arsenide.—J. R. Knight 999
Crystal Growth of Gallium Arsenide using Carbon Boats.—J. R. Knight 1001
Methane Oxidation initiated by Electrical Discharge.—M. Barber and Dr. J. Cuthbert 1001
Internuclear Distances of Methyl and Methylene Radicals.—George Glockler 1002
Polarographic Determination of Vanillin.—Jiří Davídek 1003
Spectrophotometric Determination of the Electron Affinities of Some Diatomic Molecules.—J. Jortner and U. Sokolov 1003

BIOCHEMISTRY

Structure of Collagen.—Prof. G. N. Ramachandran and V. Sasisekharan 1004
Effect of Temperature on the Concentration of Free Radicals in Melanins from *Allium cepa*.—M. L. Edwards, Dr. G. A. Kerkut, Dr. K. A. Munday and K. Leach 1005
Adenosine Triphosphate- and Coenzyme A-dependent Decarboxylation of Oxalate by Extracts of Peas.—John Giovanelli and Noel F. Tobin 1006
Carcinogenic Activity of Apocholic Acid.—A. Lacassagne, Prof. N. P. Buu-Hoï and F. Zajdela 1007
Interaction of Proteins and Nucleotides in Buffered Aqueous Solutions.—Prof. Joseph R. Debro and Melvin Lee 1008
Electrophoretic Mobility of Cultured Mesodermal Tissue Cells.—D. H. Heard, G. V. F. Seaman and I. Simon-Reuss 1009
Identification of 20β-Hydroxy-pregn-4-ene-3-one in Luteal Tissue from Pregnant Whales.—John Kristoffersen, Torleiv Lunaas and Weiert Velle 1009
Antibodies blocking Neutralization of Penicillinase by the Homologous Anti-serum.—Dr. Nathan Citri and Gill Strejan 1010

PHYSIOLOGY

Effect of Temperature on the Retinal Slow Potential of the Horseshoe Crab.—Dr. R. Kikuchi, K. Naito and S. Mnagawa 1011
Binding of Calcium Ions by the Aorta.—Dr. I. Gordon Fels 1012
Effects of Certain Androgenic Steroids on the Increase of Endometrial Carbonic Anhydrase caused by Progesterone.—Dr. Kazukuni Yamashita and Kenichi Kurouji 1013
Effect of Allylisopropylacetamide on Liver Metabolism.—Prof. C. H. Gray, Margaret Kelly and V. Moses 1014
Inhibition of Emotional Reactions by Phenothiazine Tranquillizers.—Dr. Max Taeschler and Dr. Aurelio Cerletti 1014
Further Evidence for Phosphatidic Acid as the Sodium Carrier.—Dr. Mabel R. Hokin and Dr. Lowell E. Hokin 1016
Impairment of Erythropoiesis by Irradiation.—Dr. C. W. Gurney and Nancy Wackman 1017
Development of the Islets of Langerhans in Man.—Patricia M. Robb 1018

PATHOLOGY

Serological Tests for Toxoplasmosis.—D. G. Fleck 1018
Effect of a Magnetic Field on Sarcoma 37 Ascites Tumour Cells.—Mrs. Indumati L. Mulay and Prof. L. N. Mulay 1019
Association of Detectable Antibodies produced by *Haemonchus* spp. Infections in Cattle, with Serum Globulin Fractions.—J. G. Ross 1019

HÆMATOLOGY

Significance of the Presence of Lewis Substances in Serum during Infancy.—Dr. Sylvia D. Lawler and Ruth Marshall 1020
Detection of *C* Reactive Protein by Fluorescent Antibody Techniques.—Dr. Robert Goldwasser and Dr. Rachmiel Rozansky 1020

HISTOCHEMISTRY

Nature of the Sinus Lining Cells of the Spleen.—R. F. Dorfman 1021

MICROBIOLOGY

A Superior Fat-synthesizing Single-spore Strain of *Lipomyces*.—D. R. Cullimore and Dr. M. Woodbine 1023
The Cytochrome of *Pasteurella tularensis*.—M. Mizuhara and Dr. M. Yamanaka 1024
Pseudomonadaceae as a Source of Bacterial Contamination in Tissue Culture.—Dr. M. Likar 1025

BIOLOGY

Sun Navigation in Birds?—Dr. Klaus Schmidt-Koenig; C. J. Pennycuick 1025
Bundles of Follicles in Adult Romney Ewes.—D. F. G. Orwin 1026
Independence of Temperature of the Rate of Ageing in *Drosophila subobscura*.—Jean M. Clarke and J. Maynard Smith 1027
Further Evidence of Polar Movement of Nutrients in Plants.—Prof. John Caldwell 1028
Staining Plastids in Chlorophyll-deficient Mutant Plants.—W. R. Childers 1029
Nothofagus Pollen in the London Clay.—Ma Khin Sein 1030
Proteolytic Activity of Crude Stem Extracts from Normal and Tumour Tissues of Plants.—Prof. C. Gainor and F. D. Crisley 1031
Fungal Colonization of a Developing Salt Marsh.—Dr. G. J. F. Pugh 1032
Molybdenum and the Fixation of Nitrogen in *Myrica* Root Nodules.—Dr. G. Bond and Dr. E. J. Hewitt 1033
Gibberellin Action on Growth of Seedlings in the Absence of Photosynthesis.—Alan H. Haber, William L. Carrier and N. Jean Enochs 1034

GENETICS

Non-disjunction of the Sex chromosomes in the Male of *Drosophila melanogaster*.—P. J. Kelsall 1035
Determining Mating Type in *Neurospora* without Crossing Tests.—Prof. H. Branch Howe, jun. 1036

CHAPMAN & HALL

THE EARTH, THE PLANETS AND THE STARS

Their Birth and Evolution

By K. E. EDGEWORTH

D.S.O., M.C., F.R.A.S., M.I.E.E.

A critical review of the theories of planetary and stellar evolution. The argument is developed in such a way that it should appeal to the professional astronomer, but the book is written in simple and straightforward language so that it can be readily understood by the ordinary reader. Mathematics in the text have been kept to a minimum, thus facilitating the task of the beginner, while the mathematically-minded reader will find most of what he wants in a very full Appendix. *Ready 28 June. Illustrated. 25s.*

*

A NEW BOOK FROM REINHOLD PUBLISHING CORPORATION

THE ENCYCLOPEDIA OF MICROSCOPY

Edited by GEORGE L. CLARK

A companion volume to the *Encyclopedia of Spectroscopy*, this comprehensive and masterly treatment of 26 kinds of microscopy is a work of major significance which will become a landmark in its subject. In 140 specially written articles, internationally recognized experts survey the broad field of microscopy, including every conceivable aspect of electron, electron mirror and field emission microscopy. The work will be of inestimable value to everyone who uses a microscope. *Ready 28 June. Illustrated. £10*

37 ESSEX STREET, LONDON, W.C.2

SIMA

a unique source of INFORMATION on scientific instruments

There are two kinds of knowledge; knowing and 'knowing where to find out'. With science and technology developing so rapidly, no one can hope to be fully informed on every worthwhile new technique or new equipment.

Here are three ways in which 'knowing where to find out' can help you:

(1) If you already know the answer to your problem but don't know who makes the most suitable equipment SIMA can tell you.

(2) If the answer to your problem depends on whether someone has already developed suitable equipment, SIMA will know if it exists and can tell you where to get it.

(3) If you just have a problem, SIMA can often tell you whether someone has already found the answer to it and has developed equipment to meet it.

Where do SIMA get their information? From two sources. One is The British Scientific Instrument Research Association (BSIRA) which is constantly engaged in research and maintains extremely comprehensive libraries and files. The other is the membership, consisting of over 180 companies engaged in all these fields of instrumentation:

OPTICAL & OPHTHALMIC — LABORATORY & ANALYTICAL — KINEMATOGRAPHIC
ELECTRONIC & NUCLEONIC — MEDICAL & X-RAY — PROCESS CONTROL & AUTOMATION
ENGINEERING & INDUSTRIAL — NAVIGATIONAL & SURVEY

The Scientific Instrument Manufacturers' Association could be your most valuable source of such information and you will find them very helpful on *any* question about scientific instruments.

the SIMA enquiry service — Over 180 manufacturers with one address

SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION OF GREAT BRITAIN
20, QUEEN ANNE STREET, LONDON, W.1. *Telephones—Secretariat Langham 4251 Enquiry Service Imperial 6000*

Space donated by member BELLINGHAM & STANLEY LTD. *Manufacturers of Polarimeters, refractometers, interferometers, and spectrometric apparatus.*

CO-OPERATION IN THE EXPANSION OF HIGHER EDUCATION

THE strength of a modern economy depends on its industrial vigour, and this in turn on technology, or the continuous application of scientific knowledge. All are based on the creative capacity of man and on his education. Accordingly, an adequate supply of scientists, engineers and technicians is a major factor in economic growth, and recognition of this led the Organization of European Economic Co-operation to establish in 1958 its Office for Scientific and Technical Personnel, with the main task of assisting member countries to increase their scientific and technical man-power, in quality as well as in quantity. Major aspects of the programme of this Office include forecasting future needs for scientific and technical man-power; determining the investment required in education and training facilities to meet those needs; modernizing methods of teaching and curricula in mathematics and science subjects in the schools; training and re-training teachers; and facilitating international exchange of information and personnel in this field.

When the Office was established in 1958, few member countries had adequate statistics on their position with regard to man-power, and still fewer on future requirements. The statistical procedures for producing such data had no international standard, nor were there standards for academic qualifications or international equivalents. As a first step, therefore, the Office arranged a conference on "Techniques for Forecasting Future Requirements of Scientific and Technical Personnel" at The Hague in November 1959, at which a series of papers was presented on such subjects as economic growth and the man-power factor; educational planning in the light of economic requirements; the role of statistics in forecasting the demand for, and supply of, scientific and technical personnel; and intellectual resources and the growth of higher education.

These papers and brief summaries of the ensuing discussion have now been published under the title *Forecasting Manpower Needs for the Age of Science**. The Office clearly proposes to work on very similar lines to those of the U.S. National Science Foundation, and it needs no more than a glance at such an article as "More Universities" in *The Westminster Bank Review* of February to appreciate how closely the programmes of both bodies bear on current problems in Britain. It is obvious, too, from recent addresses of university authorities, such as that of Sir Charles Morris, vice-chancellor of the University of Leeds, at a meeting of the University Court last November, or that of Dr. B. V. Bowden at the annual meeting of the Court of Governors of the Manchester College of Science and Technology in the same month, how keenly they are aware of the importance of these factors. Dr. Bowden, for example, stressed particularly the importance of adequate expansion in engineering and urged re-consideration of the establishment of a technological university on a large enough scale. At Leeds the questions of numbers, standards and balance of studies, alike in relation to general education and to the demands of the community for particular categories of qualified men and women, are obviously much in mind.

The article in *The Westminster Bank Review* is concerned more especially with the inquiry now being undertaken by the Robbins Committee, and surveys very fairly the situation which confronts Britain in both university and technical education with the growth of secondary education. It indicates very clearly some of the decisions which will have to be made at an early date—decisions which should be based on facts that are ascertainable, not on prejudice or tradition. Apart from the question of how large is the supply of students potentially capable of profiting by higher education, whether or not at a university, and taking account both of the 'bulge' and of the nation's needs for trained man-power, including overseas needs, the article stresses the vital importance of nourishing among as many young people as possible the ability to think for themselves and to question what Galbraith has termed broadly 'the conventional wisdom'. This does not imply that such education should necessarily be given at a university, though it is true that many students who fail to obtain a good degree have benefited from the broadening influence of university education, and that it is wrong that anyone of proved ability should be excluded from a university purely for lack of space.

The difficulties of university expansion are not to be under-estimated, or attributed simply to a reluctance of many university authorities to lower high academic standards, or to existing concepts of the optimum size for a university, any more than it should be assumed that an academic education is the best type of higher education for every promising student. Much more thought could well be given here to the function of the colleges of technology; and the question of balance, particularly in relation to the technical colleges, is extremely important. There are problems of staff, of the siting of new institutions, and of finance, and it is imperative that, so far as possible, these decisions should be based on careful analysis of the facts, and on critical and creative analysis by the Robbins Committee.

Whether, therefore, we agree or not with the view put forward at the conference at The Hague already mentioned by Dr. Alexander King, director of the Office for Scientific and Technical Personnel (Organization for European Economic Co-operation), that education is

* Organization for European Economic Co-operation: Office for Scientific and Technical Personnel. *Forecasting Manpower Needs for the Age of Science*. Pp. 141. (Paris: Organization for European Economic Co-operation; London: H.M. Stationery Office, 1960.) 7.50 N.F.; 10s. 6d.; 2 dollars.

essentially a long-term process which requires planning on a careful assessment of the broad pattern of needs, and that forecasting of man-power needs is thus an essential pre-requisite to the elaboration of sound educational programmes, some such forecasting must have a place in planning the expansion of higher education of all types. This is just as true in such a country as the United Kingdom as it is in the lesser-developed countries. University expansion must be planned in relation to the potential needs, even although it must be planned in relation to available resources of staff, buildings and equipment and finance. In fact, as Mr. Erik Jb. Schmidt recognizes in his paper on economic growth and the man-power factor, the physical limits to a rapid development of technical education are likely to be greater obstacles than the economic limits, and this is especially true of staff.

Mr. Schmidt visualizes a definite vertical build-up of the educational system in any country from the elementary to the most-advanced scientific stages, with appropriate balance between the several professional and vocational sectors, varying from country to country. He stresses the need for flexibility, and suggests that even with the present imperfect knowledge of the most appropriate structure, much could be done to improve the effectiveness of existing systems. Better vocational counselling, the differentiation of education and the development of various types of education in a system of graduated steps, shortening the period of education by eliminating obsolete material in courses and using modern methods of instruction and more differentiated use of teachers are all means by which existing teachers could be used more efficiently and the demands made both on them and on students minimized.

Mr. P. H. Coombs in his paper seeks to indicate the assumptions which could form a basis for educational planning, the changes required and the basic steps which should be taken. Obviously the first step is a clear analysis and appraisal of the existing educational system; but there was a wide difference of opinion at the Conference as to the practicability of defining the educational aims and goals most appropriate for the period covering the next ten years. The Danish delegate thought that reliable long-range forecasts were scarcely possible, whereas Prof. M. Vermot Gauchy went much further than Dr. H. Goldstein or Dr. S. Moberg, who merely discussed the role of statistics in forecasting supply and demand or indicated methods and techniques used in Sweden for forecasting specialized man-power requirements, in that he presented an elaborate statistical technique for measuring a myriad of future needs within each individual economic sector. Nevertheless, all three appear by implication to accept the practicability of Mr. Coombs's third and fourth steps: determination of the economic resources and internal changes required to achieve these goals, and of the adequacy of institutional and political mechanisms and processes for educational planning and decision-making, for mobilizing educational resources and for executing agreed plans.

Mr. Coombs lays much stress on the contribution of the economist to the planning of education, and much more work of the type that Mr. Vaizey has undertaken in "The Costs of Education" is certainly needed. Nevertheless, the report does not ignore the inherent conflict between the planning and guidance of man-power on one hand and the freedom of choice in a free society on the other. Moreover, Prof. P. de Wolff's paper on intellectual resources and the growth of higher education, which leads to the general conclusion that available reserves seem to allow for a considerable expansion of participation in higher education, points also to the importance of international co-operation in improving and unifying the methods for obtaining comparable data in this field. Prof. de Wolff also agrees with Dr. Goldstein that there is a sound basis for identifying talent among comparable social groups but stresses the considerable influence of environmental factors.

Generally, it may be said that the Conference agreed that as yet no established and unique methodology exists for forecasting in respect of scientific and technical personnel, and it would be unwise to regard forecasts as a rigid and infallible guide to policy. Forecasts of demand should indeed be increasingly comprehensive, but long-term forecasts require supplementing by short-term checks, and overall analyses and projections require supplementing by detailed examination, industry by industry, and by type of qualification. Apart from the attention given to the reserves of intellectual potential, stress was laid on the opportunities for increasing the efficiency of educational systems in utilizing talent, and this aspect must become of increasing importance as the cost of education continues to rise. Further, it is interesting to note not only the agreement at the Conference as to the value and opportunity for international co-operation in methodology in this field but also the recognition of the special problems of the under-developed countries in the supply of scientists, engineers and technicians, particularly in respect of special needs for investment in education within the framework of national economic development. As the writer in *The Westminster Bank Review* remarks, more than 6,000 places at British universities are at present taken by Commonwealth students, and a further 4,000 places by other foreign students. Despite the growth of universities in Colonial and Commonwealth territories, the general improvement in educational standards throughout Africa and Asia will lead increasing numbers of Commonwealth students to seek to finish their education at British universities and colleges of technology.

It would be folly to disregard this demand or to fail to provide for it as generously as possible in plans for the expansion of higher education in Britain. The existence of this need, however, only illustrates further the need for close integration of the economic, scientific and technological and the human aspects of the many problems involved, and the danger of taking sectional decisions at almost any stage or level. Again, the report of the Conference of the Office for Scientific and Technical Personnel well

emphasizes the need for flexibility and for further inquiry in many directions. The need for experiment is no less urgent and should be remembered at all levels in planning the expansion of existing or the development of new universities, in the field of technological education, and in the inquiries for which the reconstituted Central Advisory Council for Education in England, under Lord Amory's chairmanship, is responsible.

It is perhaps particularly desirable that such considerations should be given due weight at conferences like that on specialization in schools convened early in March by the Education Group and the Manchester Branch of the Institute of Physics and the Physical Society, at which Lord James of Rusholme uttered strong words against forcing the choice between arts and science too early, and again in considering the reconstruction of technical education. Something more than better links between schools and technical colleges is required. The proposals in the White Paper on Technical Education (see *Nature*, March 4, p. 701) aimed at broadening the education received by the students, adapting the system more closely to the needs of industry, increasing the variety of courses offered and reducing the existing wastage should receive unqualified welcome; but these will not remove the need for much more creative and constructive thought about the relations of technical and technological education, and the relations of both to the schools and the universities. Moreover, while the national and economic aspects of these interrelated problems are rightly kept in the forefront, the human aspects are no less important, and it is unfortunate that only too often these tend to receive the least-discriminating treatment, or to be made the play-ball of party political prejudice. One very important reason for welcoming the co-operation between industry and educational institutions and authorities of all types, which the White Paper on Technical Education emphasizes, is the contribution it could make to eliminating this tendency.

A DIVERSITY OF THEOLOGICAL SPECULATIONS

Immortal Longings

By Stephen Findlay. Pp. 192. (London: Victor Gollancz, Ltd., 1961.) 21*s.* net.

The Firmament of Time

By Dr. Loren Eiseley. Pp. viii + 183. (London: Victor Gollancz, Ltd., 1961.) 16*s.* net.

WHEN confronted with a good book with which he fundamentally disagrees, the first duty of a reviewer is to direct attention to its merits, and in the case of Mr. Findlay's volume they are considerable. *Immortal Longings* is a very well-written and well-informed study of the case for human immortality and the survival of bodily death. It surveys the familiar ground of metaphysical and theological beliefs, arguments and theories with admirable lucidity and concludes with a brilliant summary of the present situation in psychical research. I can at least cordially agree with Mr. Findlay in his opinion that philosophers and scientists would do well to pay more attention than they are wont to 'parapsychology'. The upshot of Mr. Findlay's critical study is almost completely negative. At the end 'immortal longings' remain no more than longings and personal immortality a faint possibility. To justify a position almost the exact opposite of Mr. Findlay's would need a book as long as his, and here I must note only some objections to his treatment of the subject. He rightly sees that the Christain belief in immortality depends on belief in God and in revelation. It is a pity that his chapter which touches on this basic theme is inadequate. A destructive criticism of the traditional theistic 'proofs' in their traditional form is not enough, and even this meagre ration of argument is imperfect. Can one, for example, fairly state the teleological argument without some reference to the evolution of mind? A process which issues in the capacity to understand itself, the evolution of the theory of evolution, has, one might think, at least some *prima facie* appearance of purpose; and, Can Kant be so far ignored as to omit all reference to the moral argument? Theistic philosophy has survived Hume's scepticism and moved on, just as science has survived his radical scepticism of causation and necessary connexion and moved on.

The negative conclusion about God and revelation vitiates Mr. Findlay's discussion of the resurrection of Christ. Those who first believed it accepted it as a culminating point in a revelatory process, apart from which it would have no significance, and the situation is the same to-day. The long section on empirical evidence for survival, though, as already remarked, excellently done, seems to me to be dominated by the presupposition that any hypothesis, however complex and conjectural, is to be preferred to that of survival, so that sometimes we seem to be invited to explain the incomprehensible by the inconceivable. This is particularly notable in the interesting discussion of the 'cross-correspondence' data. Almost at the end of his book Mr. Findlay introduces a new and disturbing factor—the mind-body relation. "The whole trend of modern neurology", he writes, "is towards regarding mind and brain as the subjective and objective aspects of the same thing." One could wish that he had elaborated this dictum by explaining what possible meaning it can have. What is this 'thing' which has two such different aspects and is itself presumably neither the one nor the other? This late appearance of the 'unknowable' is confusing for it raises the question whether perhaps it may be immortal!

Dr. Eiseley's book is a very different matter, though, in a wide sense, it bears on the same subject—the nature and destiny of man. It does not incite us, however, to argue or criticize but rather to listen to a prophetic word, to enter into the vision of a man of science contemplating the whole range of life and its development. The titles of the chapters are sufficient indication of the scope and trend of the author's thought: "How the World Became Natural"; "How Death Became Natural"; "How Life Became Natural"; "How Man Became Natural"; "How Human is Man?"; "How Natural is 'Natural'?". The book is in fact a prolonged meditation on the meaning of Nature. The dangers and terrors of the present and the future are not concealed; but the conviction emerges that there is that in man which transcends Nature, and, in Kierkegaard's words, "through the eternal we can conquer the future". Anyone who is depressed in spirit by read-

ing Mr. Findlay's account of the prospects of immortality might find through reading Dr. Eiseley's *The Firmament of Time* a renewal of hope. These two books, diverse as they are in spirit and method, have one common character—they are both written with such grace and mastery of English prose that it is a pleasure to read them. W. R. Matthews

ADVANCES IN ANALYTICAL CHEMISTRY

Advances in Analytical Chemistry and Instrumentation

Vol. 1. Edited by Charles N. Reilley. Pp. vii + 445. (New York : Interscience Publishers, Inc. ; London : Interscience Publishers, Ltd., 1960.) 90*s*.

THIS is the first of a series of volumes, to be published at annual intervals, the purpose of which is to select new ideas and instrumental techniques in analytical chemistry and subject them to a detailed, critical review by acknowledged practical experts.

The advisory board controlling this publication is composed of eighteen chemists of such eminence that the success of the series could unequivocally be predicted purely from a consideration of the personalities involved. The excellence of this initial volume serves, however, to confirm any such predilection in the mind of a reviewer.

E. H. Swift and F. C. Anson have contributed a welcome and authoritative chapter on the use of Iwanow's thioacetamide as a substitute for the traditional, but toxicologically objectionable, hydrogen sulphide reagent in general analysis. From kinetic hydrolysis studies, the best conditions for the employment of thioacetamide are established for acid and alkaline media. Detailed practical examples are quoted for the separation of many cations using this unique reagent.

C. A. Horton discusses trends in the macro- and micro-determination of fluorine. This is an element of considerable commercial interest, and it also is important in the fields of water treatment (dental caries) and archæological dating. The review is detailed and up to date, and includes discussion of Prof. Belcher's new reagent, cerium 1,2-dehydroxyanthroquinonyl-3-methylamine-*N*-*N*-diacetic acid.

W. Schoniger presents a chapter on organic micro-analysis. The oxygen-flask micro-combustion method is discussed side by side with the more classical micro-chemical methods. The chapter begins with some most useful advice on weighing procedures.

Gas chromatography attracts wide interest because of its delicacy and specificity in micro-analysis. R. B. Seligman and F. L. Gager have contributed an excellent paper on modern detector systems, with particular comment on the great sensitivity of the newer ionization devices. R. F. Godda presents a similarly detailed treatment of the successful application of near infra-red spectrometry in the 1–3μ region. This paper provides a series of valuable tabular information on absorption spectra in this unique range, together with useful comment on the application of various commercial infra-red spectrophotometers.

Approximately a quarter of this first volume is devoted to a critical review by H. Flaschka and A. J. Barnard of the analytical usages of the tetraphenylboron reagent, which for almost a decade has been employed extensively for the gravimetric determination of potassium. The authors describe the applications of tetraphenylboron to the other alkali metals in titrimetric determinations both of volumetric and electrometric type, and also its uses in spectrophotometry and turbidimetry. The applications of tetraphenylboron in the identification and estimation of organic compounds are also described. W. Reinmuth contributes a review chapter on the theory of electrode processes, and the charge transfer phenomena associated with reversible and irreversible systems. Problems associated with electrode materials, salt effects, surface active species, etc., are all discussed critically and the article provides an extensive bibliography of papers on this most complex subject.

This series presents in a compact form the authoritative views of acknowledged experts on techniques and theoretical advances in the physical and analytical fields, and will undoubtedly be welcomed by the research worker and the academic student alike.

D. T. Lewis

FAST-NEUTRON HANDBOOK

Fast Neutron Physics

Edited by J. B. Marion and J. L. Fowler. Part 1 : Techniques. (Interscience Monographs and Texts in Physics and Astronomy, Vol. 4.) Pp. xiv + 983. (New York : Interscience Publishers, Inc. ; London : Interscience Publishers, Ltd., 1960.) 218*s*.

FAST neutron physics, in the present context, concerns the study of interactions of atomic nuclei with neutrons of energies between a few keV. and about 50 MeV. The past decade has seen a rapid growth of interest in this field. The stimulation is in large part due to the increasing demands of reactor designers. There is also, however, a better appreciation of the value to the theoretician of data from nuclear reactions which involve neutrons, since the interpretation of such data does not require the inclusion of complicating Coulomb effects. In such a rapidly growing field the description of the latest techniques has been confined mostly to research reports, and little effort has been spent on trying to summarize and evaluate developments. A core of basic technology has, however, been built up, and the present book attempts to summarize this and to provide a standard reference work for the field. The book is the first of two volumes ; the second, which is still to be published, will deal with the experimental results and their interpretation by present-day nuclear theories.

This first volume is subtitled *Techniques*, and is concerned primarily with the technical problems of the production, detection and shielding of fast neutrons. It consists of twenty-four articles by authorities in their particular field. The scope of the work can be appreciated by considering the four sections under which the articles are grouped. Section 1 concerns neutron sources, both radioactive sources and the most important neutron-producing reactions. Section 2, "Recoil Detection Methods", has articles on detection by photographic plates and by cloud chambers as well as by proportional and scintillation recoil spectrometers. Section 3 considers other neutron detectors, including 'long counters',

solid and gaseous scintillators, helium-3 neutron-spectrometers and fission detectors. Finally, Section 4 treats a number of special topics such as time-of-flight techniques, neutron-flux measurements, collimation and shielding of neutrons and health hazards. In many of the articles information is assembled which has previously been scattered through the literature, or merely passed informally between laboratories; notable in this regard are the articles on flat response counters, on neutron collimation and shielding, and on neutron-producing targets. The work is still reasonably up to date in spite of the fact that it was written in 1958—this shows that a clear need existed for a reference book of this type. The usefulness of the book is enhanced by excellent bibliographies, and these, together with the wide range of topics that it covers, will make it of great value to all research workers in the fast-neutron field.

To end with some mild criticism, the book shows evidence of a lack of balance in assembling the material. A particular example of this is that there are no tables of the emitted neutron energy *vs.* the bombarding particle energy for three commonly used neutron-producing reactions, $D(d,n)^3He$, $T(p,n)^3He$ and $T(d,n)^4He$, whereas such tables are included for several rather uncommon reactions such as $^{51}V(p,n)^{51}Cr$.

Furthermore, I was left with the impression that many of the articles could have been shortened appreciably without affecting their scope. One can understand the problem that the editors must have had in combining so many parts into one comprehensive whole, but it might have been better if they had exerted their authority somewhat more firmly regarding the length of the contributions. The result of their failure to do this has been that the book is priced well beyond the means of most physicists and will be relegated to the library shelf instead of the experimenter's desk.

J. H. MONTAGUE

MATHEMATICS FOR THE BIOLOGIST

An Introduction to the Mathematics of Medicine and Biology

By J. G. Defares and I. N. Sneddon. Pp. xii + 663 + 6 plates. (Amsterdam: North-Holland Publishing Company, 1960.) 85*s*.

THIS is a comprehensive introduction to mathematics for the aspiring biologist and clinician. On second thoughts 'perspiring' would be the better word. The authors are painstakingly meticulous in the correctness of their approach, and some pages read almost like a university text-book in analysis. The reader for whom the book is intended is supposed to have ceased the active study of mathematics several years ago, and it is not difficult to imagine his reactions when confronted with the definition of a field on page 4, and what is virtually a Dedekind section on page 5. However, after learning about convergence, permutations, the binomial theorem and partial fractions, on page 47 the reader is being told in elaborate detail how to plot a point on a graph. This unevenness is explained by the interests of the two authors. One is a mathematician, the other a physiologist, and it is usually evident which chapter has been written by which.

The authors guide the readers from limits and derivatives, through the standard techniques of integration and partial differentiation to differential equations, partial as well as ordinary. On the way, he will learn about logarithms, gamma functions, Laplace transforms and Fourier series, so it will be seen that the scope is indeed comprehensive.

Throughout, the theory is illustrated by a wealth of practical examples. They tend to be mainly drawn from physiology, but one excellent feature of them is the emphasis placed on the construction of a suitable model. Throughout these examples, however, all points found from practical experiments lie exactly on a straight line or other appropriate curve. No indication is given as to what the biologist is to do when this is not the case, as will so often happen.

The authors deliberately exclude the theory of statistics from their scope; but one would have hoped for a little guidance in dealing with this situation in a book intended for biologists, whose results are usually so very variable.

There are one or two mistakes in the examples and in the solutions of the problems. Example 13 in Chapter 4 has a bad slip, and in example 4 of Chapter 6, x should tend to zero. I could make no sense out of paragraph 10 in Chapter 10, and there are some serious misprints in equation 2 on p. 290. The six plates seem useless and their exclusion might possibly reduce the rather high cost. The printing and lay-out are excellent throughout.

To sum up, then, this book is not likely to convince the biologist that mathematics is easy or exciting. As a reference book, it may be extremely useful, but as a text-book, it is much too difficult and laborious for the reader for whom it is intended.

J. F. SCOTT

RECENT ADVANCES IN ENTOMOLOGY

Annual Review of Entomology, Vol. 6

Edited by Edward A. Steinhaus and Ray F. Smith. Pp. vii + 470. (Palo Alto, Calif.: Annual Reviews, Inc., 1961. Published in Co-operation with the Entomological Society of America.) 7 dollars.

IN the six years since this *Review* was started it has already made itself indispensable. It fulfils its declared object exactly, which was to invite specialists to provide authoritative and scholarly reviews of the literature in their particular specialties. In each volume, the editors have presented a list of titles that ranges over every aspect of entomology. The papers are all of a high level of authority, and are supported by very complete bibliographies, so that each takes the reader at once into the heart of the subject.

Volume 6 contains the following articles: "Darwin's Contributions to Entomology", by J. E. and C. L. Remington: "Insect Nutrition", by H. L. House; "Nutritional Factors in Insect Resistance to Chemicals", by H. T. Gordon: "Principles of Insect Cold-hardiness", by R. W. Salt: "The Biochemistry of Insect Hemolymph", by G. R. Wyatt; "The Role of Mitochondria in Respiratory Metabolism of Flight Muscle", by B. Sacktor; "Diurnal Rhythms", by Janet Harker; "The Theoretical and Practical Study of Natural Insect Populations",

by O. W. Richards; "Principles of Insect Predation", by C. S. Holling; "Biological Control of Pest Insects in Europe", by J. M. Franz; "Sampling Crop Pests and their Hosts", by A. H. Strickland; "Biology of Chiggers", by Manabu Sasa; "The Phenomenon of Industrial Melanism in Lepidoptera", by H. B. D. Kettlewell; "A Review of the Phylogeny of Mites", by T. A. Woolley; "Palæoentomology", by O. Martynova; "The Analysis of Insect Embryogenesis", by S. J. Counce; "The Chemistry of Organic Insecticides", by T. R. Fukuto; "Mode of Action of Insecticides", by C. C. Roan and T. L. Hopkins; "Ecological Aspects of Plant Virus Transmissions", by W. Carter; "Mechanism of Transmission of Viruses by Mosquitoes", by R. W. Chamberlain and W. D. Sudia; "Arthropod Vectors as Reservoirs of Microbial Disease Agents", by C. B. Philip and W. Burgdorfer; and "Transmission of Filarioid Nematodes", by F. Hawking and M. Worms. In addition there are cumulative indexes to the volumes 2–6 (Why not 1–5?).

Not all, however, are equally rewarding to the non-specialist. While most authors interpret the word 'review' to mean a general survey of a field of study, which any interested person might use as a starting point, a few, including one or two in this volume, have moved to the extreme that the editors originally said they wished to avoid: ". . . a mere concatenation of bibliographical summaries or abstracts. . .". An article that can be understood only by people already working in that field would be better placed in a specialized journal.

Apart from these that are a breathless catalogue of new facts, a few others are spoiled by being written in a language that purports to be English, but has to be mentally translated before it can be understood. "Furthermore, lifelong infection of true hibernating mosquitoes may explain, at least in part, the overwintering of virus in colder temperate regions where continuous transmission is interrupted." Why not say: "In colder temperate regions mosquitoes stop biting during the winter, but those that hibernate may act as a winter reservoir for the virus"? H. B. D. Kettlewell on "Industrial Melanism in Lepidoptera" is a model of clarity: "The canopy of all trees is washed by rain and the pollution is carried down the branches, and finally the trunk".

HAROLD OLDROYD

IN SEARCH OF RACE RELATIONS

White Man

A Study of the Attitudes of Africans to Europeans in Ghana before Independence. By Dr. Gustav Jahoda. Pp. xii+144. (London and New York: Oxford University Press, 1961. Issued under the auspices of the Institute of Race Relations.) 21*s.* net.

IN the confused and confusing field of studies called 'race relations', the general reader and the research student will welcome a book such as this one. Dr. Jahoda has succeeded in making clear the limits of his study pursued in Ghana just before independence, the methods by which he carried it out, and the conclusions he drew from it. This is a notably difficult type of study, by a European, of African attitudes to the white races. Its scientific basis is that of a psychologist who is willing to use not one but several techniques, and to discuss how far they are applicable and wherein lie their limitations.

The chapters can be arranged in three main groups: the history of White contacts with Ghana (chapter 1); the main groups of informants, school-children and adults, and the methods used to ascertain and record their views (chapters 2–6); and the final two chapters (7 and 8) in which Dr. Jahoda makes an analysis of the results of the study. He says more than once that he felt himself cramped by the limitations of the space allowed, and this is particularly evident in the final two chapters, where a fuller discussion, both of the methods of study and the results, would have been advantageous.

Among the many studies of political and economic development now being made in Africa, this field of 'attitudes' is new, neglected and important. There are two distinct yet related aspects of this problem: the attitudes of Africans to Europeans, and that of Europeans to Africans. Studies have been going on at the University College of Central Africa in both these aspects. There is obviously room in all the African countries for a development of these 'attitudes' studies on a scientific basis, which will be recognized by Africans and Europeans as being valid, objective and yielding results which can be applied to contemporary situations. It is therefore imperative to speed up the process by which African research students can receive the kind of advanced training which will enable them to work as fully equipped colleagues with Europeans. These are not studies to be rushed into in order to provide quick solutions for political and economic relationships. They require the detached, unemotional research which can validate its own methods and justify and explain its results, however unexpected or unpalatable they may appear to Africans or to Europeans.

Dr. Jahoda has provided us in this book with several ideas which form the main theoretical leads in his own work and provide suggestions for further development in subsequent studies. One of these concepts is that of the stereotype held by the members of one race about the members of another, and he emphasizes that this stereotype when acquired is "notoriously resistant to change". This complex of attitudes towards the members of another race is the result of a historical time process, and hence there is an element of "time lag" in the formation and expression of attitudes. This is probably the most outstanding contribution in the present study, and is well worth searching out in all the chapters of the book.

Another factor, illustrated in Chapters 2–5, is the difference in the attitudes of Africans with varying degrees of Western education or none at all. Hence there is no one 'African attitude', and these educationally differentiated attitudes also vary in relation to the stages of political and economic development.

Thirdly, and this concept calls for anthropological as well as psychological investigation, the Africans in this Ghana study distinguished between the British expatriates with whom they had personal contacts in the country, and the British institutions and culture which had been brought to Ghana over a long historical period. This raises in the field of race-relations studies the fundamental question of how far stereotypes and attitudes depend on personal contacts, and how far on identification with or revolt against an imported culture.

There is no index, but there is a detailed synopsis of all the chapters and a useful selected bibliography.

MARGARET READ

Lectures on Ergodic Theory

By Prof. Paul R. Halmos. Pp. vii + 100. (New York: Chelsea Publishing Company.) 2.95 dollars.

THIS book is a re-issue of one previously available under the imprint of the Mathematical Society of Japan. It consists of the notes on which Prof. Halmos based a series of lectures given at the University of Chicago in 1955, and, although it makes no claim to being an exhaustive survey, it is yet rich in content.

The lectures are, of course, addressed to pure mathematicians. Although ergodic theory had its origin in Boltzmann's development of the kinetic theory of gases, the subject, as extended by mathematicians, now encompasses a much wider field. Thus only the first few chapters, which deal with recurrence, mean and pointwise convergence, ergodicity (in the sense of metrical transitivity) and mixing theorems, have relevance to the problem of irreversibility as it appears in physics.

The discussion in these initial chapters is in terms of transformations on a measure space; afterwards, algebraic concepts are introduced and topics then considered include conjugacy and equivalence with particular reference to transformations which possess a discrete spectrum, weak and uniform topologies for automorphisms, the topological size of sets of strongly mixing, weakly mixing and ergodic transformations, and the existence of a sigma-finite invariant measure equivalent to a given measure. A list of unsolved problems is appended.

The author's style displays its customary clarity, and the lucid presentation, enhanced by informal asides, augurs well for the author's declared aim of rekindling interest in this branch of mathematics.

I. E. FARQUHAR

Impact

The Theory and Physical Behaviour of Colliding Solids. By Prof. Werner Goldsmith. Pp. xv + 379. (London: Edward Arnold (Publishers), Ltd., 1960.) 90*s*. net.

PROF. GOLDSMITH has produced a reference book which will be welcomed by those working on problems of the impact of solids, since much of the subject-matter has hitherto been available only in published papers. The book embraces a wide range of topics, and contains much factual information in the form of tables and graphs. The treatment is concise, and in many of the theoretical solutions only an outline of the main steps is given, with appropriate references to published papers.

After a survey of the classical theory of the impact of rigid bodies, the author considers vibration and wave motion in elastic bodies, and discusses problems involving the collision of elastic rods, and the impact of a rigid mass on a rod or beam. The book continues with a discussion of contact phenomena, and the effect of these phenomena in elastic problems is investigated. Impact problems involving plastic flow are considered, with a brief discussion of the hydrodynamic theory, and a more extended treatment of theories of plastic wave-propagation in rods, beams, and plates. A chapter on impact experiments includes a description of experimental techniques, together with results of many experiments involving elastic and plastic deformations. The book concludes with a chapter on the dynamic properties of materials, and the techniques used in their measurement. There is also an extensive bibliography of nearly six hundred titles.

R. P. N. JONES

Analytical Techniques for Non-Linear Control Systems

By Prof. John C. West. (Electrical Engineering Series.) Pp. 223. (London: English Universities Press, Ltd., 1960.) 25*s*. net.

THIS book describes successively the application of three techniques, namely the phase-plane and describing function techniques, and the use of random inputs, to the analysis of non-linear control systems.

In an approach basically similar to that used in a previous book by the same author on linear servomechanisms, the application to specific simple systems is introduced at an early stage in the description of each technique. Application to more complex systems is then described and the analysis developed from these examples to more general considerations concerning the technique. The same non-linear systems are analysed by each technique and a comparison of results made which forms a particularly interesting connecting link between the three separate groups of chapters.

The style is clear and concise, and the author does not allow mathematical complication to obscure the fundamental principles he describes. This, together with the basic approach of progressing from the particular to the general at each stage, leads to a text which may be easily read as an introduction to the subject, but which at the same time takes the reader further than would an introductory work. Indeed, the material in parts reaches, albeit briefly, almost as far as the present development of the subject permits.

This book fills a definite gap in the existing literature in the field of control mechanisms and is a useful addition to it.

E. M. DEELEY

Physics of Semiconductors"

By A. F. Ioffe. Pp. xi + 436. (London: Infosearch, Ltd., 1960. Distributed by Cleaver-Hume Press, Ltd., 1960.) 84*s*.

THIS is an English translation of the Russian book published in 1957 which was reviewed in *Nature* (Dec. 7, 1957). Some amendments and additions have been made in the preparation of the translation; the bibliography has been extended and a subject index has been added. A twenty-page section has been added on materials for thermoelements which provides an excellent discussion of impurity effects and solid solutions, and of the attainment of the required high electrical conductivity, high thermoelectric power and low thermal conductivity. The ten pages of "Conclusions" reflect the late author's particular interest in the phenomenon of low carrier mobility in certain materials and the dilemma posed by apparently very short mean free paths.

The book indicates the state of semiconductor physics up to 1957, and the treatment throughout is aimed at giving physical insight into fundamental processes without excessively detailed analytical discussion. It is felt that the book is successful in attaining its intended objectives and can prove stimulating in certain areas of contemporary semiconductor research.

R. E. BURGESS

CENTENARY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

By Dr. JAMES R. KILLIAN, jun.

Chairman of the Corporation, Massachusetts Institute of Technology, formerly Special Assistant for Science and Technology to the President of the United States

ONE cannot live in the atmosphere of a great research and educational institution, renewed year after year by youth, with its hopes and energies, and by students, old and young, with their dreams and discoveries, without acquiring a faith in the power of intelligence to achieve a future of peace and order among all peoples.

This faith was strengthened during the recent celebration of the centenary of the Massachusetts Institute of Technology, when some of the world's most eminent intellectual leaders met at the Institute to exchange ideas on how greater good may be sought through greater knowledge. The Institute was honoured by their presence, and we believe the occasion proved a fruitful one for them.

More than 150 men and women from many professional fields in 35 countries participated in a conference on the prospects and implications of scientific and engineering education for the world. Later there were provocative discussions by such thinkers as Aldous Huxley, Prof. J. Robert Oppenheimer, Sir John Cockcroft, Prof. Chen Ning Yang, the Right Hon. Philip J. Noel-Baker, Prof. George W. Beadle and Prof. Peter B. Medawar, on what the future holds in science, the arts, industry and arms control. The Right Hon. Harold Macmillan and Mr. Dean Rusk, Secretary of State, gave notable addresses which cast new light on the complexities of international affairs.

No attempt will be made here to summarize the many points of view that were expressed in the discus-

Fig. 1. Rogers Building, the first permanent home of the Massachusetts Institute of Technology, in Boston, Massachusetts. The photograph was taken around 1915, although the building was completed in 1866

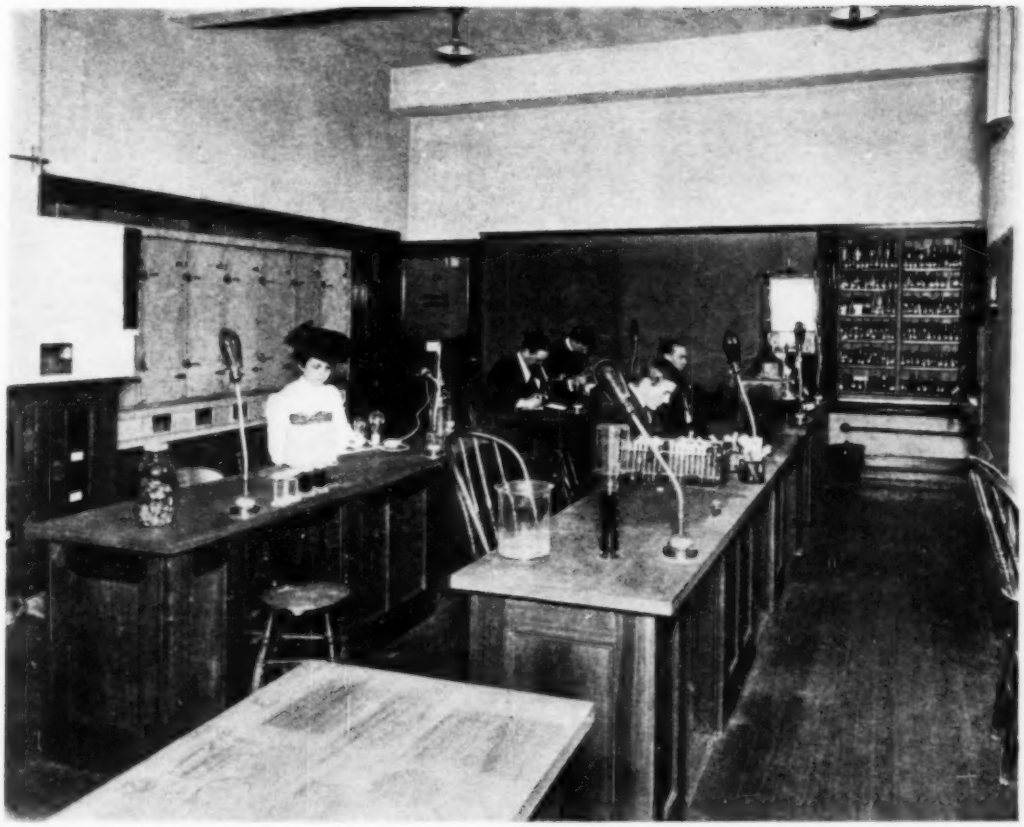


Fig. 2. Photograph of a research laboratory taken when the Institute was in Boston (1895). The students are of graduate-level and are performing experiments in electrolysis and the study of cultures in chemistry

sions. There was no intention that clear-cut conclusions should be sought, and no final solutions of the problems which press on the world from every side were offered. Yet, there was an atmosphere of hope, of awareness of our magnificent opportunity to imagine a better human community, and, through a new blending of the sciences, the social sciences and the humanities, to devise the new strategies required to move toward a better human community.

The expectations and intentions of to-day are closer than one might suppose to those which a hundred years ago led to the founding of the Institute. By the end of the second decade of the nineteenth century, the economic expansion of the United States, with the growth of industry and agriculture, was calling forth new public attitudes toward education and toward science and technology. There were strong forces leading to the popularization of knowledge, including a growing awareness by people from all walks of life that science could provide a better life.

This understanding brought into being lyceums and mechanics' institutes, the forerunners of a new pattern of education, the means for the application of scientific principles to the practical arts, and the development of a new and closer relationship between the scholar and the citizen.

Concurrently, there was a growing demand for universal, free, public education. It was in 1837 that Horace Mann, the eloquent apostle of "well-appointed and efficient means for the universal education of the people", became the first full-time secretary of Massachusetts' new State Board of Education, and in this post led a transformation of the State's schools and set a new pattern of public education for the nation.

In the midst of this national ferment a Virginian, William Barton Rogers, who was to found the Massachusetts Institute of Technology, began to form ideas for a new kind of educational institution to respond to the needs of a growing industrial society.

Rogers had held the chairs of natural philosophy and chemistry in William and Mary College, and of natural philosophy in the University of Virginia. He had served as head of the Virginia State Geological Survey, an experience that broadened his understanding of the social and economic importance of science.

He recognized that science should no longer remain the esoteric concern of a few learned and cultivated men. It was in the public interest that it be the concern of all. The economic expansion of the country, the gradual opening of the West, the growth

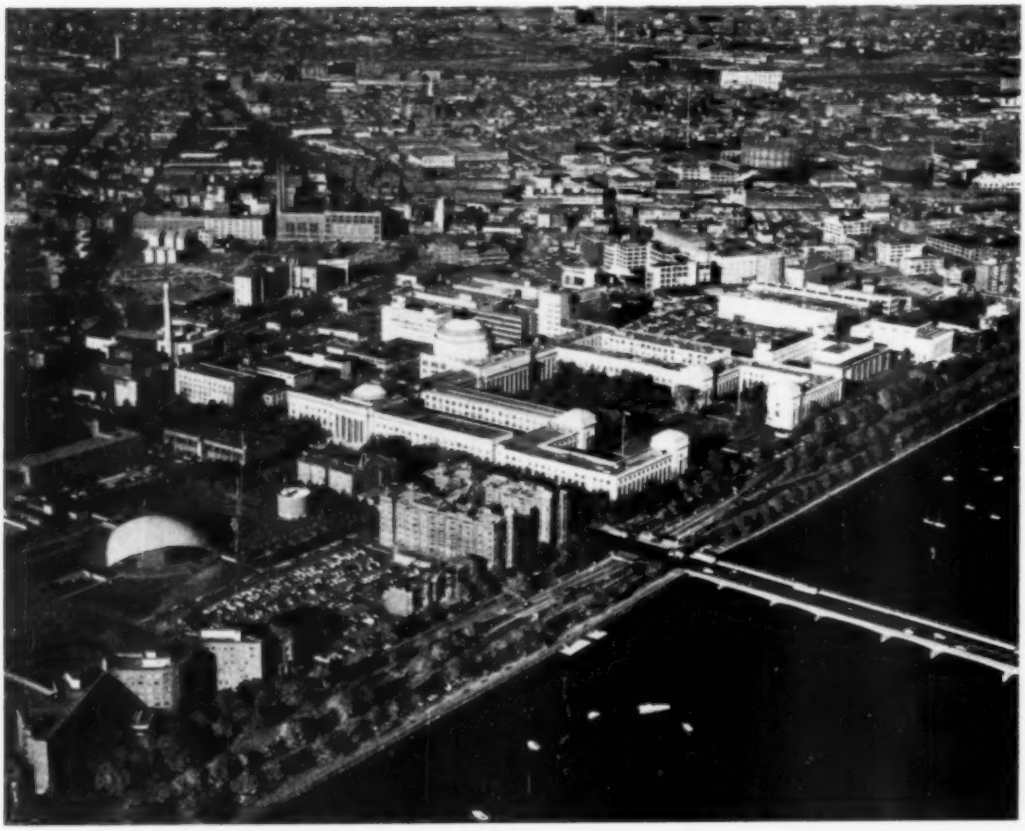


Fig. 3. Aerial view of the Massachusetts Institute of Technology. Kresge Auditorium and the Institute Chapel (the triangular and cylindrical shaped buildings) are on the left. From left to right, immediately facing the Charles River, are Baker House Dormitory, Graduate House Dormitory, the Great Court with the Main Building of the Institute, Hayden Memorial Library, and Walker Memorial Student Union. (*Photo: Lawrence Lowry*)

of industries, navigation, transportation, mining, and agriculture, increased the need for a deeper knowledge of the resources of the nation.

What treasures were buried in its rocks, hidden in its forests, lying beneath its waters? How could Nature be controlled to offer better opportunities for manufacturing, transportation, agriculture, and, most important, men? The existing educational institutions were inadequate in attitude, facilities and personnel to meet these demands.

College education was still centred on the study of the classics. Natural science was considered of relatively little importance in comparison. The colleges, as a rule, still believed in 'training the mind', for which purpose Cæsar, Plutarch and Euclid were considered unsurpassed. Engineering as a professional study was almost non-existent in the university system.

A few schools, notably Yale and Williams, had hesitantly and half-heartedly attempted to teach the application of scientific principles to the productive arts. Rensselaer Institute under Amos Eaton and the United States Military Academy under Sylvester Thayer had already pioneered in the training of science teachers and civil engineers, respectively.

Even so, the United States was definitely lagging in technological education relative to Europe, where engineering had long been recognized as a profession. The École Polytechnique in Paris, the Bergakademie at Freiburg, the Technische Hochschule in Zurich—all emphasized a highly intellectual, scientific and analytical approach to education for the technological services demanded by State and industry.

Since his move to the University of Virginia, Rogers had become immersed in college administration. In 1844 he was chosen chairman of the Faculty, a post equivalent to that of the university's chief executive. This position strengthened Rogers's administrative and organizational skills, while affording him full opportunity to ponder Jefferson's educational ideas stressing the use of science and technology for the betterment of society.

His experience led Rogers to question seriously the future of science in the current curricula of existing colleges. Dearth of facilities, improperly trained personnel, and above all the lack of understanding by educators seemed to foretell a dim future for education in science and engineering. It became apparent to Rogers that only through the formation of a new school, free from the vested interests of

traditional education, devoted specifically to polytechnic education, could science and its practical application be placed in its proper perspective in the general system of American education. Such circumstances led Rogers in 1846 to prepare this famous "Plan of a Polytechnic School".

Virginia, he concluded, was not then the place to start such innovations. Rogers turned to Boston as the site for consummation of his ideas on polytechnic education. This city, with its flourishing arts and sciences, the centre of factory- and machine-conscious New England, and philanthropically minded families, was a logical place to promote and establish a school devoted to technology.

The proposal attracted nation-wide interest, although it was not until 1861 that Rogers saw its culmination when the "Act to Incorporate the Massachusetts Institute of Technology" was passed by the Massachusetts Legislature "for the purpose of instituting and maintaining a society of arts, a museum of arts, and a school of industrial science, and aiding generally by suitable means the advancement, development and practical application of science in connexion with the arts, agriculture, manufacture, and commerce".

The forerunner of a new type of educational institution, this was fully tuned to the changing technological character of the nation. It was to serve as the model for many other schools throughout the world. The work of Rogers undoubtedly did much to pave the way for the Morrill Act of 1862, which led to the establishment of America's unique system of land-grant colleges.

In his plan for a new kind of university, Rogers stressed four fundamental principles:

First, he emphasized the importance of being useful. He had no sympathy with the prevailing view that the practical professions lacked dignity, or that utility corrupted liberal education. He was one of the earliest advocates of what J. B. Conant has described as the philosophy of the modern American university, "a philosophy hostile to the supremacy of a few traditional vocations, a philosophy moving toward the social equality of all useful labor".

Next Rogers stressed the educational gain derived from building a college programme around a professional objective. He recognized that the discipline, the thoroughness, and the motivation inherent in a professional programme have educational values. He refused to admit of any inevitable conflict between specialism and liberal education.

Rogers's next principle, that of learning by doing, he expressed through the laboratory method of instruction. While this idea was not original with him, he gave it its first systematic application in the

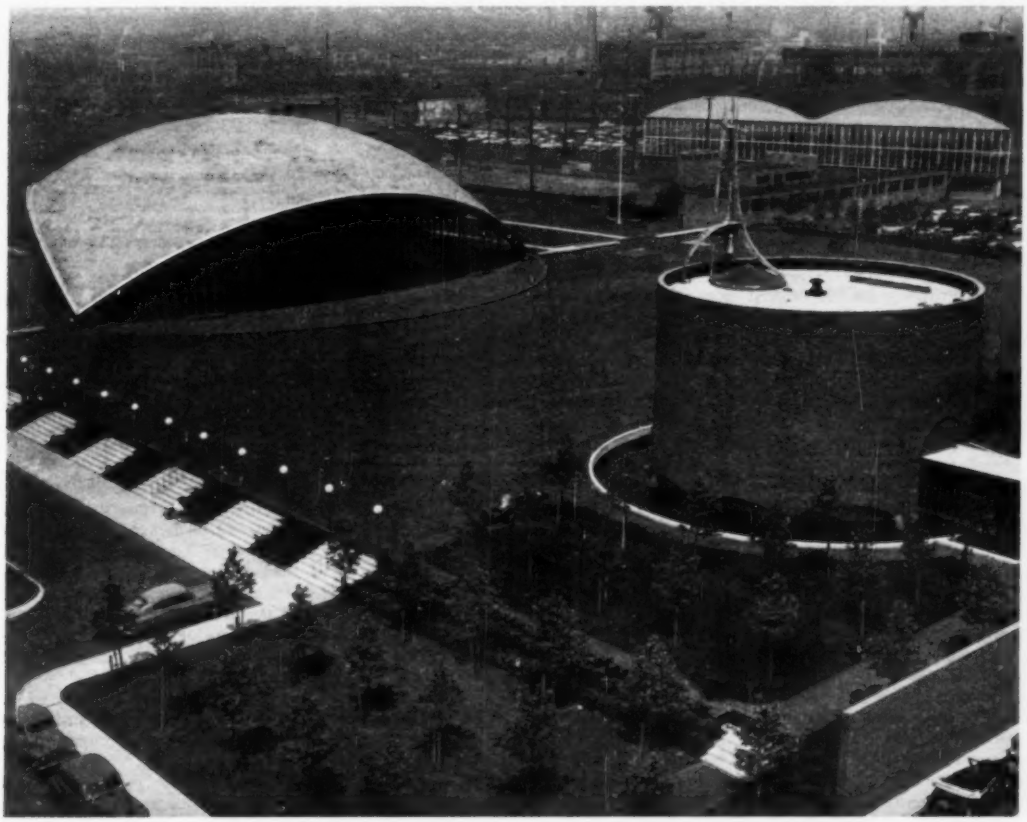


Fig. 4. Kresge Auditorium (left) and the Institute Chapel (right) were designed by Eero Saarinen and are focal points of the Massachusetts Institute of Technology community

Fig. 5. The Karl T. Compton Memorial Laboratories, which house the Computation Center and the Research Laboratory of Electronics at the Massachusetts Institute of Technology

United States. In his educational thinking, Rogers always stressed method; in a time of scepticism, he had faith in the scientific method. He foresaw the far-reaching effects on higher education of the spirit and method of research, the concept which holds that learning thrives best in an atmosphere of creativeness and not in one limited to imitativeness and anti-quarianism. American universities were later to assimilate this idea from the German universities; but Rogers's idea was indigenous.

Next, Rogers was emphatic in his belief that learning principles is more important than learning facts. "We believe", he said, "that the most truly practical education, even in an industrial point of view, is one founded on a thorough knowledge of scientific laws and principles, and which unites with close observation and exact reasoning", and, note this, "a large general cultivation".

He wanted the humanities taught along with engineering and science. He anticipated the need, met by only a few institutions even to-day, of a new kind of institution with its centre of gravity in the sciences instead of the classical studies, but with the humanities and social sciences fully represented and enthusiastically supported as full partners.

In his original prospectus of 1846 Rogers had the boldness and foresight to dream of a destiny for his institution. "I doubt not", Rogers wrote, "that such a . . . school would finally expand into a great institution . . ."!

Rogers laid down the grand design, and successive presidents carried the institution steadily forward toward the quality of institution Rogers had doubted not would be achieved. Francis Amasa Walker, distinguished economist and Civil War general, gave validity to the design and brought the Institute to national prominence.

Richard Cockburn Maclaurin, a Scotsman from New Zealand, who was educated as both lawyer and physicist at the University of Cambridge, attracted to the Massachusetts Institute of Technology financial resources that for the first time began to be commensurate with the Institute's responsibilities and moved the Institute to its present more ample home in Cambridge, Mass. Karl Taylor Compton provided a new thrust by strengthening the sciences and expanding graduate study and research.

Where does the Institute stand at the end of its first hundred years in relation to the aims and hopes of its founder? How has the innovation served the nation? What is the record?

The Massachusetts Institute of Technology has been an educational pioneer since its founding. It virtually created the modern profession of chemical engineering and was the first technological institution to recognize and provide for economics as an impor-

An Invitation to Subscribe to
this expanded Pergamon International Research Journal

INTERNATIONAL JOURNAL OF

AIR & WATER POLLUTION

The INTERNATIONAL JOURNAL OF AIR POLLUTION has changed its title and coverage to enable articles to be included on the many significant aspects of water pollution and to bring together in one medium results obtained by research workers in all divisions of air and water pollution.

CONTENTS OF THIS LATEST ISSUE

F. WIPPERMAN : Die Maximal Konzentrationen eines sich in turbulenter Stromung ausbrietenden Gases ; K. D. HAGE ; The influence of size distribution on the ground deposit of large particles ; W. P. ELLIOTT : The vertical distribution of gas from a continuous source ; G. T. CSANADY : Some observations on smoke plumes ; C. L. MATEER : Effect of the weekly cycle of air pollution on solar radiation at Toronto ; A. P. ALTSHULLER and I. COHEN : The gas phase reactions of nitrogen oxides with olefins ; A. P. ALTSHULLER and A. F. WARTBURG : Ozone interactions with plastic and metallic materials in a dynamic flow system ; E. R. STEPHENS, E. F. DARLEY, O. C. TAYLOR and W. E. SCOTT : Photochemical reaction products in air pollution ; G. H. HEPTING and C. R. BERRY : Needle blights of White Pine—the interpretation of fume damage ; N. JAWORSKI, G. W. LAWTON and G. A. ROHLICH : Aerobic sludge digestion ; J. M. SYMONS, R. E. McKINNEY, R. M. SMITH and E. J. DONOVAN Jr. : Degradation of nitrogen-containing organic compounds by activated sludge ; Book Reviews.

Published Bi-monthly

BOARD OF EDITORS

Air Pollution Section

DR. R. S. SCORER
Department of Mathematics, Imperial College, London.

G. NONHEBEL
Imperial Chemical Industries.

DR. C. M. FLETCHER
Department of Medicine, Post-Graduate Medical School, London.

DR. W. KLUG
Institut für Meteorologie, Technische Hochschule, Darmstadt.

DR. JAMES P. LODGE
Robert A. Taft Sanitary Engineering Center, Ohio.

Water Pollution Section

DR. B. A. SOUTHGATE
Director, Water Pollution Research Laboratory, Stevenage.

PROF. W. WESLEY ECKENFELDER, JR.
Civil Engineering Department, Manhattan College, New York.

PROF. EDMUND LECLERC
Centre Belge D'Etude et de Documentation des Eaux, Liège.

Assisted by an Honorary Editorial Advisory Board

Manuscripts for editorial consideration should be sent to the Member of the Board of Editors most conveniently located.

A copy of this journal and details of subscription rates gladly sent on application

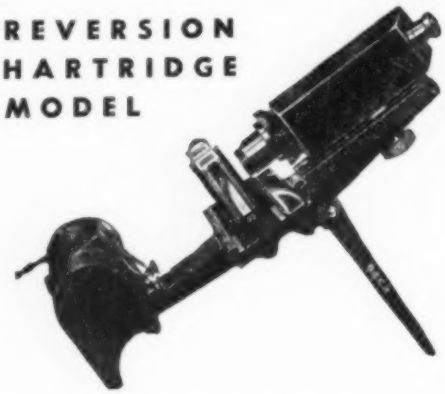
PERGAMON PRESS

OXFORD LONDON NEW YORK

Headington Hill Hall, Oxford. 4 & 5 Fitzroy Square, London W.1. 122 East 55th Street, New York 22, N.Y.

BECK SPECTROSCOPE

REVERSION
HARTRIDGE
MODEL



For all spectrometric work, absorption or emission, the reversion method gives the most accurate results. Readings can be obtained to an accuracy of 1 ÅU.

Full particulars forwarded on application

R. & J. BECK LTD.
69/71 MORTIMER STREET, LONDON, W.1

MSE

DISPLAY OF
MSE CENTRIFUGES
and **LABORATORY EQUIPMENT**

MSE cordially invite you to visit a special display of the COMPLETE RANGE of MSE CENTRIFUGES and OTHER LABORATORY EQUIPMENT to be held in the MSE OFFICES, 8–28 SPENSER STREET, LONDON, S.W.1 (off Victoria Street, opposite Army & Navy Stores—nearest Underground Station, Victoria or St. James's Park).

Monday 19th June—Friday 23rd June, 1961
10 a.m. to 5 p.m. (7.30 p.m. on Wed. 21st June)

Light Refreshments.

MSE representatives will be pleased to demonstrate and answer queries.

Measuring and Scientific Equipment Ltd.
Spenser Street, London, S.W.1 VICtoria 5426

ENDECOTTS
TEST SIEVES
For Accuracy!

POCKET INTERCHANGER SIEVES

'ENDROCK' TEST SIEVE SHAKER

TEST SIEVES
B.S. 410: 43 U.S. Standards
and Tyler Equivalents

We operate a Recovering Service

Consistent mechanical action—
saves valuable time of skilled personnel

ENDECOTTS (FILTERS) LTD. Phone: LIBerty 8121/2/3
Dept. B Lombard Rd., London, S.W.19. Grams: Endfilt, London

Resistance Wires

TOPHET 'A' — 80/20 Nickel-Chrome — gives best results in all high temperature applications.

TOPHET 'C' — Nickel-Chrome-Iron — lower priced but excellent for use at slightly lower temperatures.

CUPRON — Copper-Nickel—low temperature coefficient alloy for use at low temperatures.

BALCO — High and uniform temperature coefficient alloy.

EVANOHM — The best available material for super precision resistors. Highest specific resistance and lowest temperature coefficient.

★ *For complete data on all our resistance alloys and stainless steel wire, write for a copy of our Resistance Handbook.*

GILBY-BRUNTON LTD
Head Office & Works:
SEAMILL, MUSSELBURGH, SCOTLAND
Telephone: Musselburgh 2369
London Office: 47 WHITEHALL S.W.1
Telephone: WHitehall 6058

tant element in the education of the engineer. The Institute was the first school to establish courses in aeronautical engineering, architectural engineering, chemical engineering, food technology, industrial biology, marine engineering, and naval architecture. It established the first collegiate programme in architecture.

The Institute's contributions to education continue to-day to find new expression over a wide range. One striking current example is the work of the Physical Science Study Committee, devoted to creating a new, complete physics course for secondary schools.

The Institute is at present taking the leadership in upgrading and modernizing the education of engineers. Its Electrical Engineering Department has led the way with a drastic overhaul of its curriculum, which embodies a more fundamental approach to electrical engineering—an approach which has prompted acclaim in industry as well as in education. This spirit is now finding rapid acceptance through the School of Engineering.

The Massachusetts Institute of Technology awards 13·6 per cent of the nation's total output of doctorates in engineering and 9·5 per cent of all Master's degrees in engineering. The number of engineering doctorates awarded by the Institute is more than double the number awarded by the second-ranking institution. In this critical area of education (only about 700 engineering doctorates per annum are at present awarded in the entire nation), the Institute has led the country in the number of doctorates awarded in almost all the professional fields of engineering.

The Institute now awards approximately 7 per cent of all the U.S. doctorates in physics. On no other single campus in the United States have so many doctorates in physics been awarded.

The Institute has gained exceptional strength from the quality and cosmopolitan character of its student body. Its 3,600 undergraduates and 2,700 graduate students are a highly select group, and in their origins they probably represent a wider geographical spread than any other student body in America. Typically, Massachusetts Institute of Technology freshmen rank in the top 10 per cent of their high-school graduating classes; the first-year class of 899 students in 1960 was drawn from 677 secondary schools distributed through almost every State and in many foreign countries.

In the graduate school more than 500 American and foreign universities are represented among the student body.

Harvard and Massachusetts Institute of Technology stand first and second respectively, and far ahead of most other institutions, in the number of National Merit Scholarship recipients enrolled. They also lead the country in the number of students receiving General Motors Scholarships and National Science Foundation Fellowships who elect to study in these two institutions.

In its service to the nation, the Institute has played a part that has demonstrated it to be one of the most significant sources of national security and strength in the United States. In recent years it has created and managed the Lincoln Laboratory, out of which has come the *SAGE* system of Air Defense and the concept and design of the *DEW* Line, the early warning line which has been vital to the deterrent power of our strategic striking force.

The Instrumentation Laboratory has pioneered in the development of inertial guidance for missiles, space-vehicles, aircraft, and submarines. Out of this Laboratory have come designs, components and systems which have resulted in industrial production running into hundreds of millions of dollars: for example, the guidance systems used in the *Polaris*, *Thor* and *Titan* missiles. *Thor*, with its 1,500-mile range, was the nation's first operational intermediate-range ballistic missile.

The Research Laboratory of Electronics, with its wide-ranging programme of basic research, has been a well-spring for new concepts and new technology important both to advancement of defence and industrial technology.

From its beginning a hundred years ago, the Institute's resources have thus been brought powerfully to bear on the development of America's industrial strength. The development of every technically based industry has been quickened by research done at the Institute or by its graduates serving in industrial research, engineering, or management capacities.

Massachusetts Institute of Technology graduates have helped to create our modern urban environment and its unequalled array of transport systems and public work. They have brought a command of the methods of science, engineering and management to the defence of the nation, to the achievement of a higher standard of living, and to the advancement of public and private health.

In addition to its contributions to science and engineering, the Institute has been, from the beginning, a centre of management education, a contribution that now finds formal expression in its young and vigorous School of Industrial Management. Industry's growing dependence on engineers in management is confirmed by a recent study which revealed that almost half the Institute's graduates in engineering eventually occupied positions in management, many within five years of their graduation.

Through leadership positions in American industry, the Institute's graduates have contributed to the strength and prosperity of the nation. Some 1,500 alumni of the Institute are presidents of private companies and institutions in the United States; about 1,200 are vice-presidents. The Institute heads the list of educational institutions the graduates of which (more than 1,400) appear in *Who's Who in Engineering*—a number almost double that of the next ranking institution.

At present the Massachusetts Institute of Technology probably has the most comprehensive and varied research programme in the physical sciences and technology to be found in any one place in the world. It has at present under way 900 separate research projects. There is scarcely any aspect of American science and technology that is not touched—and advanced—by its creative activity. Thus, the Institute stands to-day as a generative force, with the opportunity before it to achieve a new order of service to America, through both research and education.

Major among the developments of the past two decades has been the strengthening of the humanities and social studies. The Center for International Studies has been established, the School of Humanities and Social Science has been formed to give formal focus and recognition to programmes in these fields. Political science has been added as a degree-granting programme.

The Massachusetts Institute of Technology has moved steadily, as Rogers clearly hoped it would, toward becoming a university polarized around science.

RECENT ADVANCES IN THE BIOCHEMISTRY OF GLYCOGEN AND STARCH*

By Dr. W. J. WHELAN
The Lister Institute, London

GLYCOGEN, and the components of starch, the largely unbranched amylose and the highly branched, glycogen-like amylopectin, were the first polysaccharides to be synthesized enzymically *in vitro*. Several factors helped in this achievement and in the subsequent rapid progress in the nineteen-forties. The substrate, α-D-glucose 1-phosphate, can be readily obtained in large quantity; the progress of synthesis of the chain-forming α-1,4-linkage is very easy to measure; and the enzymic synthesis of the branch points is accompanied by characteristic changes in the iodine-staining properties of the polysaccharides and their susceptibility to degradation by exo-enzymes. Ten years ago the enzymic synthesis and degradation of these polysaccharides could be reviewed with the feeling that further progress would consist only in adding detail to the already firm outlines.

However, the nineteen-fifties saw the widespread discoveries of the sugar nucleotides and their involvement in carbohydrate biosynthesis. Glycogen and starch have been caught up in these discoveries and the whole conception of their biosynthesis *in vivo* from glucose 1-phosphate is now held to be incorrect. The new evidence points to both polymers originating from uridine diphosphate glucose, polymerized by 'glycogen synthetase'[1] or a corresponding plant enzyme, referred to here as 'amylose synthetase', first reported last September[2]. Phosphorylase is thought to be an agent only of degradation. Other discoveries have been scarcely less disturbing to the older hypotheses. For example, rabbit muscle-phosphorylase *a*, the first glycogen-metabolizing enzyme to be crystallized, is not the predominant form in resting muscle[3]. Instead it is phosphorylase *b*, which dimerizes to the *a* form by an adenosine triphosphate-dependent reaction during the *in vitro* manipulations of isolation[4]. Because phosphorylase *b* requires adenosine monophosphate for activity while *a* does not, a reconsideration of the interrelation of *in vivo* processes must follow. The reverse conversion of phosphorylase *a* into *b* by *PR*-enzyme has also been re-examined. *PR*-enzyme had been thought to be a factor removing a prosthetic group (hence the initials), but after the discovery of the halving in molecular weight when rabbit-muscle *a* enzyme turns into *b* (ref. 5), the initials could be held to apply to phosphorylase rupture. We now know that they stand equally for phosphate removal[6]:

$$\text{phosphorylase } a \xrightarrow{PR\text{-enzyme}} 2 \text{ phosphorylase } b + 4PO_4^{3-}$$

Other enzymes which have been re-scrutinized are those splitting the branch linkages of glycogen and amylopectin. The plant enzyme (*R*-enzyme), attacking amylopectin, has proved to be two enzymes, one specific for the natural macromolecule and the other attacking only the small branched oligosaccharides formed during α-amylolysis of amylopectin[7]. Correspondingly, the activity of the animal enzyme, amylo-1,6-glucosidase, is due to two components[8], but in this case both activities, those of a hydrolase and of a transglycosylase, are necessary to complete the debranching process.

The transglycosylase is one of a vast group of enzymes discovered in the past ten years, the existence of which went unsuspected for lack of suitable means of detection. Paper chromatography provided that means and was instrumental in the discovery in potato juice of an enzyme the specificity of which has not yet been matched by that of any mammalian enzyme. This catalyst, *D*-enzyme[9], redistributes α-1,4-bonds in starch-type polymers. Maltotriose is the smallest molecule on which it exerts any rapid action. It is first converted into maltopentaose and glucose, for the enzyme prefers to transfer glucose residues severally rather than singly. There is no hydrolysis and therefore no change in the average size of the molecules. The enzyme represents a major activity in potato juice and is presumably implicated in starch metabolism. When the action is coupled with that of hexokinase and adenosine triphosphate, to convert glucose into the 6-phosphate, the enzyme is driven to form long, amylose-like chains from maltodextrins and merits consideration as yet another rival to phosphorylase for starch synthesis[10]. Enzymes which likewise redistribute α-1,4-glucosidic bonds but appear to act readily on maltose are also known now in plants[11] and animals[12,13]. Separate but similar catalysts have been discovered in potato (*T*-enzyme)[13] and rabbit muscle[14]. These also transfer α-glucose from maltose but reposition the sugar at C-6, not at C-4, forming the trisaccharide panose. The chemistry of this action is identical with that of the polysaccharide-branching enzymes, *Q*-enzyme in plants, amylo-1,4→1,6-transglycosylase in animals. *T*-enzyme is separable from *Q*-enzyme, so just as with *R*-enzyme (see above) it seems that separate systems are necessary for the same reaction according as to whether the substrate is an oligosaccharide or a polysaccharide. In fact, of the enzymes which it has been customary to involve in the cycle of glycogen–starch synthesis and degradation, only the branching enzymes seem to have retained their places unchallenged. This situation may, however, simply reflect the comparatively scant attention these enzymes have received.

Biosynthesis of Glycogen and Starch

The chain-forming process. The synthetic pathway to glycogen based on uridine diphosphate glucose (Fig. 1) was first reported in 1957, by Leloir and Cardini[1], as taking place in rat liver. Since then, the enzyme has been found in muscle tissue of pigeons[15], humans[16], rabbits[17] and rats[18], in rabbit brain[19], yeast[20] and in beans[2,20a], potatoes and sweet corn[20a]. The early observations of the insolubility of the animal enzyme are probably the result of adsorption on glycogen in the microsomes, and this finding led Leloir *et al.*[2,20a] successfully to search for the enzyme in starch grains. The enzyme preparation reported is in fact a suspension of starch.

* Substance of two lectures given in the Department of Biochemistry, University College, London, on February 25 and March 2.

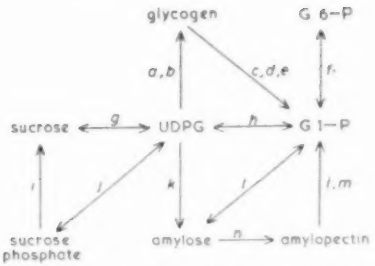


Fig. 1. Synthesis and degradation of glycogen, starch and sucrose; G 6–P, glucose 6-phosphate; UDPG, uridine diphosphate glucose; G 1–P, α-glucose 1-phosphate; *a*, glycogen synthetase; *b*, amylo-1,4 → 1,6-transglucosylase; *c*, phosphorylase; *d*, amylo-1,6-glucosidase; *e*, amylo-1,4 → 1,4-transglucosylase; *f*, phosphoglucomutase; *g*, sucrose synthetase; *h*, UDPG pyrophosphorylase; *i*, sucrose phosphatase; *j*, sucrose phosphate synthetase; *k*, amylose synthetase; *l*, phosphorylase; *m*, *R*-enzyme; *n*, *Q*-enzyme

The finding recalls Stacey's[21] suggestion that the starch grain might contain the enzymes of synthesis.

The discovery of the nucleotide pathway to glycogen explained several observations inconsistent with the idea of phosphorylase as the provider of glycogen[22]. For example, when epinephrine or glucagon are used to stimulate phosphorylase, glycogen disappears. Also the ratio of inorganic phosphate : glucose 1-phosphate in animal tissue is totally unfavourable for glycogen synthesis by phosphorylase. Glycogen synthetase action does not depend on the level of inorganic phosphate, and the conversion of uridine diphosphate glucose is essentially complete[1,13,18].

Glycogen synthetase needs a primer, and its specific requirements are similar to those of muscle phosphorylase. Thus glycogen is the most efficient primer but loses its activity after degradation by α-amylase. Polysaccharides with lower degrees of branching than glycogen are less effective and linear material does not prime[17,18,20]. The problem is therefore posed with glycogen synthetase, as with muscle phosphorylase[23], of the reason why, in order to synthesize α-1,4-bonds, the enzymes require a primer containing α-1,6-bonds and of high molecular weight. Potato phosphorylase[24] and amylose synthetase[200] have no such scruples. Work with glycogen synthetase presents experimental problems due to the instability of the enzyme and the exotic nature of the glucose-donating substrate. So far the records of 'glycogen' synthesis in fact amount to lengthening of the unit chains of the added primer by only a few glucose residues. A very curious feature of glycogen synthetase is the dependence of the activity of the animal and yeast enzymes on glucose 6-phosphate. The rat-liver enzyme[1], for example, is activated up to 15-fold by the ester, and the 6-phosphates of fructose, glucosamine and galactose can replace the glucose phosphate. The glucose moiety of the phosphate is not, however, incorporated into the synthetic polysaccharide[18], and it remains uncertain whether the effect of sugar phosphate is simply a protection of enzymic activity or something more intimate[1]. The effect has not been mentioned for the bean enzyme[2,200], but one wonders whether there is any connexion with the still unexplained occurrence of 6-phosphate residues in starch, mainly in the amylopectin component.

Branching enzymes. There is a very close correspondence between glycogen metabolism in animals and starch synthesis in plants. In fact every enzyme implicated in glycogen metabolism has its plant counterpart. Such differences as are found concern specificity, as between *D*-enzyme and its animal analogue, mentioned earlier. These differences are of two types, one concerned with group transfer and the other with the differing shapes of the plant and animal macromolecules. Thus, in regard to the latter, glycogens having 'normal' values of average unit chain-length are not attacked by potato phosphorylase, *D*-enzyme or *R*-enzyme[25]. Only when the glycogen has been fragmented, thereby opening the compact structure, do these enzymes attack it. Yet potato phosphorylase[26] has a molecular weight only 40 per cent of that of rabbit-muscle phosphorylase *a* (ref. 5). A similar comparison can be made between the plant and animal branching enzymes. Potato *Q*-enzyme synthesizes amylopectin from amylose, and will not introduce further branches into amylopectin[27]. The branching enzyme from yeast, which stores glycogen, acts on amylose to produce amylopectin but continues the branching process until the degree of branching is that of glycogen[28], about twice that in amylopectin.

Degradative Enzymes

Phosphorolysis and debranching. The plant and animal phosphorylases are exo-enzymes and in the presence of inorganic phosphate they phosphorolyse amylopectin and glycogen, respectively, until the points of branching are approached. The limits of approach by potato phosphorylase have not been measured, but Cori and Larner[29] defined those of muscle phosphorylase after finding that the residual glycogen dextrin (φ-dextrin) yielded glucose on treatment with amylo-1,6-glucosidase. This suggested a structure in which side-chains (*A* chains) had been degraded to a single 1,6-linked α-glucose residue. The outer length of each chain carrying this residue (*B* chains) was thought to be 5–7 glucose units. Walker and Whelan[8], however, found no such 1,6-bonded single glucose residues in the φ-dextrins of glycogen or amylopectin. They concluded that both the attenuated *A* chain and the outer portion of the *B* chain were each four units long. Their explanation of the appearance of free glucose during debranching is that a transglycosylase repositions glucose residues in the φ-dextrin to form the Cori–Larner-type molecule, then attacked by the glucosidase. A preparation of the glucosidase was in fact found to contain a transglycosylase which repositioned the α-1,4-bonds of maltose and maltotriose, but Illingworth *et al.*[200] report the lack of this enzyme in a purified preparation. Differences of group transfer also occur between the plant and animal debranching enzymes in that the latter seems capable only of detaching single 1,6-linked glucose residues[29] whereas *R*-enzyme only removes such side-chains when they are two units or longer[30].

α- and β-Amylases. The actions of the α- and β-amylases, endo- and exo-enzymes respectively, are now well understood. The enzymes are generally considered to be entirely specific for the hydrolysis of the α-1,4-glucosidic linkage. Certainly they do not hydrolyse the α-1,6-branch linkages but caution in rigidly defining the specificity is prompted by the recent report[31] that a 'specific' β-1,3-glucosidase also hydrolyses β-1,4-glucosidic bonds when these are proximate to a β-1,3-bond. Also β-amylase liberates both nigerose (α-1,3-diglucose) and maltose from Floridean starch[32].

The limits of action of the amylases on linear and branched amylaceous polysaccharides have been defined. The smallest natural substrate for either

enzyme is maltotriose[23,24], hydrolysed to glucose and maltose, but it is maltotetraose which is hydrolysed at rates comparable with those of polysaccharides. The branch linkages offer partial and absolute protection to adjacent 1,4-bonds. In its endwise progression from the non-reducing chain ends of amylopectin and glycogen, β-amylase is unable to hydrolyse the last α-1,4-bond before a 6-substituted glucose unit[25,26]. The fragmenting α-amylases can carve the 6-substituted glucoses away from the polysaccharide, but not in the form of the 1,6-linked disaccharide isomaltose. One or more 4-substituted glucose residues remain in the fragments (α-limit dextrins). Thus the smallest α-limit dextrin formed by malt α-amylase is panose (4-α-isomaltosylglucose), by human-salivary, pig-pancreatic and *Aspergillus oryzae* α-amylases it is the tetrasaccharide 4-α-panosylglucose, whereas *Bacillus subtilis* α-amylase yields a pentasaccharide, tentatively assigned a structure in which α-maltose is joined to C-6 of the central glucose residue in maltotriose[24].

Glycogen-Storage Diseases

A practical outcome of work in a largely academic field of research has been the explanation of the inherited disorders characterized by abnormal deposits of glycogen in the storage organs. The subject has been reviewed very recently[22] and will be mentioned here only briefly. Of the six types of disease listed by Stetten and Stetten[22], four are associated specifically with the impairment of a particular enzyme of the glycogen cycle. In the two other types no specific enzymic lesion has yet been detected. When the deficiency resides in glucose 6-phosphatase (Von Gierke's disease) or phosphorylase (type VI) the glycogen in the diseased tissue has a normal structure, but has undersized outer chains; when the debranching enzyme is deficient (type III) or a low degree of branching in the type IV disease, assumed to be due to lack of branching enzyme.

If glycogen synthetase and phosphorylase are to be thought of as opposing forces then a lack of the latter should lead to excessive amounts of glycogen. This indeed happens in type VI disease, known in human muscle and liver. The normal structure of the resulting glycogen implies that the branching enzyme is in a concentration sufficient to cope with the extra glucose polymerized. It was observed very early in work with phosphorylase that synthesis from glucose 1-phosphate with crude rabbit-muscle extracts led to amylose-like material[23], that is, the chain-lengthening and chain-branching enzymes were in an entirely unfavourable ratio for glycogen formation. Glycogen synthetase activity in rabbit muscle is, however, less than 1 per cent of that of phosphorylase and the balance of synthetase with branching enzyme must therefore be more favourable for glycogen synthesis. The activity of synthetase in rat muscle is known to be sufficient to account for the amounts of glycogen being synthesized[18,27], but the level of glucose 6-phosphate in rat liver, necessary to activate the enzyme (see above), is so low as to limit the rate of synthetase action[1]. The excessive relative activity of muscle phosphorylase can be seen as yet another reason for relegating the enzyme to a place in the catabolism of glycogen, saving only that the supply of adenylic acid could regulate the action of phosphorylase *b*.

Tests of activity of enzymes in heart and liver from cases of type II disease failed to reveal an enzyme deficiency which could account for the excess of glycogen[28]. The results are, however, disturbing in revealing a total absence of glycogen synthetase in four, and a marked deficiency in two, of the six organs examined. The results are obviously incompatible with the excess of glycogen found in the tissues and at face value point to the existence of yet another pathway to glycogen.

Enzyme Structure

Many of the different amylases and phosphorylases have been crystallized and some facets of their structures are emerging. The most significant recent advance in the α-amylase field has been their recognition as metallo-enzymes[29]. All contain at least one atomic proportion of calcium, essential both for the activity of the enzyme and to preserve its integrity against the depredations of proteases. Possibly the calcium maintains the amylase molecule in a configuration unfavourable for proteolysis. *B. subtilis* α-amylase also contains an atom of zinc, uniting two protein moieties, both of which are active in the presence and absence of zinc. End groups of some α-amylases have also been identified.

Human-[40], rabbit-[41], lobster-muscle[42] and potato[26] phosphorylases contain pyridoxal phosphate. Although the rabbit- and lobster-muscle enzymes are reversibly inactivated on removal and re-addition of pyridoxal phosphate, removal being effected by acid, reduction with sodium borohydride renders the pyridoxal acid stable yet does not destroy enzymic activity[42]. The reduced *a* and *b* enzymes are, moreover, still interconvertible. Rabbit and human *a* enzymes contain 4 molecular proportions of pyridoxal phosphate, the *b* forms and potato phosphorylase 2 proportions. Although lobster- and rabbit-muscle phosphorylases *a* are converted into the *b* forms by lobster- or rabbit-muscle phosphorylase phosphatases[42] (this interchange of enzymes does not apply in the $b \rightarrow a$ reaction), the lobster enzyme does not alter in molecular weight[42] but the muscle enzyme is halved in weight[5]. Likewise dog-liver phosphorylases *a* and *b* are equal in weight[44]. Human-[40], rabbit-[32] and lobster-muscle[42] *b* enzymes require adenylic acid for activity, but dog-liver phosphorylase *b* is enzymically inactive[45]. Human- and rabbit-muscle phosphorylases are immunologically identical[46], but dog-liver and -heart phosphorylases are immunologically different[46]. The phosphate removed by phosphatase from rabbit-muscle phosphorylase *a* is attached to serine[6]. Digestion of *a* enzyme with trypsin removes both serine and phosphate as a hexapeptide, Lys. Glu(NH_2).Ileu.Ser(PO_4).Val.Arg, leaving a phosphorylase *b'*, active in presence of adenylic acid, but no longer convertible into the *a* form. Therefore serine phosphate is not concerned with phosphorylase activity.

Outstanding Problems

Of the enzymes listed in Fig. 1, only the phosphorylases[47,48] and *Q*-enzyme[49] have been crystallized. Purification of enzymes has so often led to the discovery of new catalysts and such experiments are essential preliminaries to studies of specificity. Some unsolved problems of specificity have been touched on, for example, the requirements of animal phosphorylase and glycogen synthetase for branched primers of high molecular weight. The suggestion is prompted that they may need to form an alliance between pairs of chains before adding a glucose unit. Such an alliance is the present accepted idea of the action of the branching enzymes[50]. Searching inquiries into substrate specificities require a wider

range of substrate than is provided by Nature and specific chemical modifications of amylose are being made, to provide such materials[51]. It is now known, for example, that removal of the oxygen atom of the primary hydroxyl groups in amylose renders the polymer resistant to β-amylolysis and phosphorolysis, but not α-amylolysis[52].

Phosphorylase has been cited as an example of an enzyme capable of performing a transformation *in vitro* which it is not called on to do *in vivo*. Another such example is provided by the enzyme capable of the direct biosynthesis of sucrose from uridine diphosphate glucose (Fig. 1). This enzyme has now been assigned the reverse role *in vivo*, synthesis of sucrose being believed to take place via sucrose phosphate[53]. Another case where reconsideration may be necessary is with the hydrolases. Many of these are now found to transfer to sugar hydroxyls as well as to water. Calculations show that the affinity of the enzyme for hydroxyls in the alternative receptors must be far greater than for water[54] and the possibility thus emerges that the *in vivo* function of such an enzyme may have nothing to do with hydrolysis.

There are some carbohydrases the function *in vivo* of which is still a matter for conjecture. Prominent among these are the amylases. β-Amylase occurs in plants in large amounts—animals seem not to require it—but no enzyme of comparable activity occurs along with the amylase to cope with its product of action, maltose. The enzyme occurs both where starch is abundant, in cereals, or absent, as in the soya bean. α-Amylases in the digestive tract are easily accounted for but what is the function of the small amounts of α-amylase that pervade most living tissue? Fig. 1 is a conventional representation of glycogen and starch metabolism and is incomplete, in that it offers no means of increasing or decreasing the total number of polysaccharide molecules. Possibly α-amylase functions in the glycogen-storage organs by multiplying the number of priming nuclei by hydrolysis. Given a supply of glucose, *D*-enzyme can do the same thing and can also assist in removing primer, as explained elsewhere[55]. It is worth noting also that Fig. 1 contains no means of creating primers where none existed. α-Amylase decreases the number of α-1,4-bonds, *D*-enzyme functions without changing their number and whereas phosphorylase and glycogen synthetase synthesize such bonds, they can only do so if preformed α-1,4-polymers are present. Is there perhaps in plants and animals a system to create the essential primer? Such systems are known in other organisms. Honey invertase acting on sucrose forms maltosylfructose and higher homologues[56], and *Neisseria meningitidis*[57] and beer lactobacilli[58] synthesize maltose from β-glucose 1-phosphate and glucose. Such a system, coupled with a transglycosylase like *D*-enzyme, could provide the necessary primer.

Beyond these studies of isolated enzymes must come attempts to integrate the enzymes into self-sufficient cycles operating *in vitro*. Though the advances in the glycogen and starch field have far outstripped those in any other field of polysaccharide biosynthesis, the goal of the multi-enzyme system may well become a practical objective only in the decade beyond this.

[1] Leloir, L. F., and Cardini, C. E., *J. Amer. Chem. Soc.*, **79**, 6340 (1957). Leloir, L. F., and Goldenberg, S. H., *J. Biol. Chem.*, **235**, 919 (1960).

[2] De Fekete, M. A. R., Leloir, L. F., and Cardini, C. E., *Nature*, **187**, 918 (1960).

[3] Krebs, E. G., and Fischer, E. H., *J. Biol. Chem.*, **216**, 113 (1955).

[4] Krebs, E. G., Kent, A. B., and Fischer, E. H., *J. Biol. Chem.*, **231**, 75 (1958).

[5] Keller, P. J., and Cori, G. T., *Biochim. Biophys. Acta*, **12**, 235 (1953).

[6] Graves, D. G., Fischer, E. H., and Krebs, E. G., *J. Biol. Chem.*, **235**, 805 (1960).

[7] MacWilliam, I. C., *Nature*, **181**, 1143 (1958).

[8] Walker, G. J., and Whelan, W. J., *Biochem. J.*, **76**, 264 (1960).

[9] Peat, S., Whelan, W. J., and Rees, W. R., *J. Chem. Soc.*, 44 (1956).

[10] Walker, G. J., and Whelan, W. J., *Nature*, **183**, 46 (1959).

[11] Nigam, V. N., and Giri, K. V., *J. Biol. Chem.*, **235**, 947 (1960).

[12] Stetten, M. R., *J. Amer. Chem. Soc.*, **81**, 1437 (1959).

[13] Abdullah, M., and Whelan, W. J., *Biochem. J.*, **75**, 12P (1960).

[14] Lukomskaia, I. S., *Dokl. Akad. Nauk*, **129**, 1172 (1959).

[15] Robbins, P. W., Traut, R. R., and Lipman, F., *Proc. U.S. Nat. Acad. Sci.*, **45**, 6 (1959).

[16] Mommaerts, W. F. H. M., Illingworth, B., Pearson, C. M., Guillory, R. J., and Seraydarian, K., *Proc. U.S. Nat. Acad. Sci.*, **45**, 791 (1959). Larner, J., and Villar-Palasi, C., *ibid.*, **45**, 1234 (1959). Schmid, R., Robbins, P. W., and Traut, R. R., *ibid.*, **45**, 1236 (1959).

[17] Hauk, R., and Brown, D. H., *Biochim. Biophys. Acta*, **33**, 556 (1959).

[18] Villar-Palasi, C., and Larner, J., *Biochim. Biophys. Acta*, **30**, 449 (1958). Leloir, L. F., Olavarria, J. M., Goldenberg, S. H., and Corminatti, H., *Arch. Biochem. Biophys.*, **81**, 508 (1959).

[19] Breckenridge, B. M., and Crawford, E. J., *J. Biol. Chem.*, **235**, 3054 (1960).

[20] Algranati, I. D., and Cabib, E., *Biochim. Biophys. Acta*, **43**, 141 (1960).

[20a] Leloir, L. F., de Fekete, M. A. R., and Cardini, C. E., *J. Biol. Chem.*, **236**, 636 (1961).

[21] Stacey, M., *Chem. and Indust.*, 110 (1943).

[22] Stetten, jun., D., and Stetten, M., *Physiol. Rev.*, **40**, 505 (1960). Larner, J., *Fed. Proc.*, **19**, 971 (1960).

[23] Cori, G. T., Swanson, M. A., and Cori, C. F., *Fed. Proc.*, **4**, 234 (1945).

[24] Whelan, W. J., and Bailey, J. M., *Biochem. J.*, **58**, 560 (1954).

[25] Peat, S., Whelan, W. J., Hobson, P. N., and Thomas, G. J., *J. Chem. Soc.*, 4440 (1954). Walker, G. J., and Whelan, W. J. (unpublished results).

[26] Lee, Y. P., *Biochim. Biophys. Acta*, **43**, 18, 25 (1960).

[27] Peat, S., Turvey, J. R., and Jones, G., *J. Chem. Soc.*, 1540 (1959).

[28] Gunja, Z. H., Manners, D. J., and Khin Maung, *Biochem. J.*, **75**, 441 (1960).

[29] Cori, G. T., and Larner, J., *J. Biol. Chem.*, **188**, 17 (1951).

[29a] Illingworth, B., Brown, D. H., and Cori, C. F., *Fed. Proc.*, **20**, 86 (1961).

[30] Whelan, W. J., *Symp. Biochem. Soc.*, **11**, 17 (1953).

[31] Parrish, F. W., and Perlin, A. S., *Nature*, **187**, 1110 (1960).

[32] Peat, S., Turvey, J. R., and Evans, J. M., *J. Chem. Soc.*, 3341 (1960).

[33] Whelan, W. J., Bailey, J. M., and Roberts, P. J. P., *J. Chem. Soc.*, 1293 (1953).

[34] Whelan, W. J., *Die Stärke*, **12**, 358 (1960).

[35] Peat, S., Whelan, W. J., and Thomas, G. J., *J. Chem. Soc.*, 3025 (1956).

[36] Sumner, R., and French, D., *J. Biol. Chem.*, **222**, 469 (1956).

[37] Villar-Palasi, C., and Larner, J., *Arch. Biochem. Biophys.*, **86**, 270 (1960).

[38] Hauk, R., Illingworth, B., Brown, D. H., and Cori, C. F., *Biochim. Biophys. Acta*, **33**, 554 (1959).

[39] Fischer, E. H., and Stein, E. A., in *The Enzymes*, edit. Boyer, P., Lardy, H., and Myrbäck, K., **4**, 318 (Academic Press, New York, 1960).

[40] Yunis, A. A., Fischer, E. H., and Krebs, E. G., *J. Biol. Chem.*, **235**, 3163 (1960).

[41] Baranowski, T. B., Illingworth, B., Brown, D. H., and Cori, C. F., *Biochim. Biophys. Acta*, **25**, 16 (1957). Cori, C. F., and Illingworth, B., *Proc. U.S. Nat. Acad. Sci.*, **43**, 547 (1957).

[42] Cowgill, R. W., *J. Biol. Chem.*, **234**, 3147, 3154 (1959).

[43] Fischer, E. H., Kent, A. B., Snyder, E. R., and Krebs, E. G., *J. Amer. Chem. Soc.*, **80**, 2906 (1958).

[44] Sutherland, E. W., *Proc. Third Intern. Congr. Biochem., Brussels*, edit. Liebecq, C., 328 (Academic Press, New York, 1956).

[45] Wosilait, W. D., and Sutherland, E. W., *J. Biol. Chem.*, **218**, 469 (1956).

[46] Henion, W. F., and Sutherland, E. W., *J. Biol. Chem.*, **224**, 477 (1957).

[47] Fischer, E. H., Krebs, E. G., and Kent, A. D., *Biochem. Preparations*, **6**, 68 (1958). Krebs, E. G., Fischer, E. H., and Graves, D. J., *ibid.*, **6**, 73 (1958).

[48] Fischer, E. H., and Hilpert, H. M., *Experientia*, **9**, 176 (1953).

[49] Baum, H., and Gilbert, G. A., *Nature*, **171**, 983 (1953).

[50] Barker, S. A., and Bourne, E. J., *Quart. Rev.*, **7**, 56 (1953).

[51] Bines, B. J., and Whelan, W. J., *Chem. and Indust.*, 997 (1960). Bines, B. J., Gunja, Z. H., and Whelan, W. J., *ibid.*, 1358 (1960).

[52] Bines, B. J. (unpublished results).

[53] Medicino, J., *J. Biol. Chem.*, **235**, 3347 (1960).

[54] Edelman, J., *Adv. in Enzymol.*, **17**, 189 (1956).

[55] Whelan, W. J., in *Encyclopedia of Plant Physiology*, **6**, 154 (Springer-Verlag, Berlin, 1958).

[56] White, J. W., *J. Amer. Chem. Soc.*, **73**, 1259 (1953).

[57] Fitting, C., and Doudoroff, M., *J. Biol. Chem.*, **199**, 153 (1952).

[58] Wood, B. J., and Rainbow, C., *Biochem. J.*, **78**, 204 (1961).

OBITUARIES

Sir David Rivett, K.C.M.G., F.R.S.

With the death of Sir (Albert Cherbury) David Rivett in Sydney on April 1, there passed from the Australian scene a man who had contributed perhaps more than any other to the present healthy state of Australian science. Entrusted as Chief Executive Officer in 1927 with the management of the Council for Scientific and Industrial Research, Rivett and his colleagues contrived, in a country woefully weak in research, to create an atmosphere in which it could flourish.

The men they appointed and supported wholeheartedly did much to inspire the confidence of the people of Australia in the economic value of research. Rivett saw clearly from the outset that his scientists had to be free to tackle their problems on as fundamental a basis as was necessary for their solution. So the men who solved some of the outstanding problems of the farmer and the pastoralist also contributed to the development of science. Nowadays, basic research is a recognized prerogative of the Commonwealth Scientific and Industrial Research Organization, which continues to be known almost as well overseas through its contributions to science as it is within Australia for its long run of outstanding practical successes. To Rivett, first and foremost, should go the credit for this.

Rivett, while chairman of the Council for Scientific and Industrial Research during 1946–49, saw more clearly, and at an earlier date than most scientific leaders throughout the world, the troubles that come to a scientific research body from secrecy. He was persecuted by minor politicians for his belief that security and secrecy are not synonymous terms. But he never ceased to fight for the principle that scientific research needs freedom, and I believe that he thereby saved his beloved Council for Scientific and Industrial Research from lethal restrictive controls.

What sort of background produced this man for whom Australia had so great a need? David Rivett was born in Tasmania in 1885, the son of a Congregationalist minister of large family and slender means. His secondary and tertiary education, mainly in the State of Victoria, had to be self-supporting. It culminated in a Rhodes scholarship which took him to Oxford for work under Sidgwick. In Stockholm, with Arrhenius, he became recognized as a physical chemist of great talent; his own notable contributions were mainly in phase rule studies and heterogeneous equilibria.

After munitions work in England he returned as a lecturer to the University of Melbourne. There he rejoined Sir David Orme Masson, who from their first meeting had had a boundless admiration for his abilities. It was inevitable that when Orme Masson resigned in 1924 Rivett should be invited to succeed his mentor. He filled the chair with distinction, but after only three years the call came to wider responsibilities with the Council of Scientific and Industrial Research; this he accepted.

Rivett was acknowledged a leader wherever he went. He was general president of the Royal Australian Chemical Institute in 1940 and 1949, president of the Australian and New Zealand Association for the Advancement of Science 1937–39, and president of the Society of Chemical Industry of Victoria in 1930 and 1931. A foundation member of the Australian Academy of Science, he was one of its first vice-presidents. The Australasian Institute of Mining and Metallurgy made him an honorary member in December 1943 for his services to the mining industry of Australia.

Well known abroad, he was president of the Society of Chemical Industry of London in 1949, and was a Fellow of the Royal Society from 1941. He was created K.C.M.G. in 1935, and held the honorary degrees of D.Sc.(Oxon.), D.Sc.(Manchester), and LL.D.(Australian National University).

Despite all his honours and distinctions, Rivett's greatest love was to visit one of his laboratories and to hear at first hand what the young research officers were doing. He was proud of the staff he had gathered, trusted its scientific ability implicitly, and fought for its freedom. No believer in the planning of science, he had the acumen to sense and oppose any impending restraint before it was openly formulated. Once one had gained his confidence he was a magnificent friend and backer; he believed in delegating responsibility and with it any credit that accrued, but in times of adversity he it was who wished to shoulder the blame.

Rivett married, in 1911, Stella Deakin, the daughter of a distinguished Australian statesman. She and their two sons survive him.

His friends throughout the world will deeply mourn his death. Their final thought of David Rivett will be of a man who gave magnificent service to the joint causes of science and humanity.

I. W. Wark

Prof. K. Koshtoyants

Prof. Kachatur Koshtoyants, whose death occurred on April 2, was a well-known figure among the physiologists of Moscow, the director of an active research institute and a stimulating and popular teacher in the University. Kachatur Sergeyevitsh Koshtoyants graduated in medicine in 1926, but his interests always lay in the field of comparative physiology, particularly that of the nervous system. During 1930–31 he had been to Holland to work in Prof. Jordan's laboratory, and five years later he was made head of the Department of Evolutionary Physiology in the Institute of Animal Morphology of the Academy of Sciences in Moscow. From 1943 onwards he was also professor of animal physiology in the University of Moscow. His more recent research dealt with neuro-muscular transmission from a comparative biochemical point of view, and he was the author of a comprehensive treatise on comparative physiology as well as of several monographs on the history of physiology in Russia. Physiologists who have visited his laboratory in Moscow will recall his kind hospitality as well as the range of his research interests, and will wish to express their sympathy to his colleagues in the University and the Academy.

Adrian

NEWS and VIEWS

Prof. Olaf Holtedahl, For.Mem.R.S.

Prof. Olaf Holtedahl, of the University of Oslo, recently elected a foreign member of the Royal Society, is best known for his geological researches on the Caledonian mountain chains of Norway, but he has also distinguished himself as an arctic and antarctic explorer, as a physiographer, and as a palæontologist. Born in 1885, he published his first paper while a student at Oslo in 1909, on Lower Palæozoic rocks of the classical Lake Mjøsa region nearby. Few cities in the world have the natural advantages of Oslo as a centre for studying geology, and no doubt inspired by the unusually fine sequence of Eocambrian–Palæozoic strata here exposed, he soon extended his researches to similar rocks in the northern district of Finnmark, much of which he mapped as a State geologist. A long list of publications during this period includes an outstanding palæontological monograph on the Strophomenidæ. In 1920 he was appointed professor of historical geology in Oslo, where he worked up the geological results of an earlier expedition to Novaya Zemlya, and a few years later he led the Lars Christensen expedition to Antarctica, afterwards editing two large volumes of reports. Attempts to correlate the geological structures of Norway and Britain gave rise to close contacts with British geologists, cemented during a Norwegian excursion which he conducted for the Geologists' Association in 1934 and resulting in his William Smith Lecture to the Geological Society of London, in 1951, on "The Structural History of Norway and its Relation to Great Britain". His two-volume survey of the geology of Norway, published in Norwegian in 1953, was written in simple form to encourage a local revival of geological studies, particularly in schools. A Russian translation appeared during 1957–58, and an abridged, re-written, version in English, with contributions from colleagues, was produced for the International Geological Congress last year.

Elmer Verner McCollum, For.Mem.R.S.

Prof. McCollum, also elected a foreign member of the Royal Society, is best known for his pioneer work on vitamins, which ranks in importance with that of Gowland Hopkins. Like Hopkins, he found that rats would not grow and thrive on 'purified' diets containing proteins, fats and carbohydrates in correct proportions. Unsuccessful attempts to make such diets life-sustaining by improving their palatability led him to the classical experiment (with M. Davis), published in 1913, showing that butter and the ether-soluble material in egg-yolk contained a growth-promoting substance lacking in olive oil and lard, which was designated "fat-soluble *A*". In 1915, McCollum discovered another growth factor, present in water-extracts of wheat germ and egg yolk, which was called "water-soluble *B*", and provisionally identified with Funk's "anti-beriberi vitamine". McCollum initiated the practice of assigning letters to the vitamins, which later proved somewhat unsatisfactory, but the combination of letters with Funk's new word gave the world a term with great popular appeal. Born in Kansas in 1879, McCollum has had a most productive scientific career. Originally trained in chemistry, he turned to biochemistry during an appointment in agricultural chemistry in Wisconsin. During 1917–46 he was professor of biochemistry in Johns Hopkins University in Baltimore, and afterwards professor emeritus. In addition to his investigations on vitamins, he has made remarkable observations on the effects of dietary deficiency of zinc and manganese. He was among the first to grasp the bearing of modern nutritional science on human welfare, and the earlier editions of his book, *The Newer Knowledge of Nutrition* (with Nina Simmonds), became the 'Bible' of a generation of nutrition workers. During recent years he has made scholarly studies of the history of the science of nutrition.

Academician A. N. Nesmeyanov, For.Mem.R.S.

Academician A. N. Nesmeyanov, another of the new foreign members of the Royal Society, has just retired from the presidency (see following paragraph) of the Academy of Sciences of the U.S.S.R. He has thus taken a leading part in the organization of science in his country. He is the director of the Organo-Element Research Institute of the Academy. He is eminent as an organic chemist, particularly for his development of the chemistry of organic molecules which contain a metal or some element outside the usual few which compose most organic chemical compounds. It is a striking fact that, in the first century of its rapid development, organic chemistry has used very few elements. With the whole Periodic Table to choose from, Academician Nesmeyanov has set its head towards a much more expansive programme in its second century. Outside his main field he has developed several fields of great importance, notably the telemerization reaction, with applications including the synthesis of ω-amino-acids, substitutions in the ferrocene nucleus, and organosilicon chemistry, including telemerizations involving silicon.

New President of the U.S.S.R. Academy of Sciences: Academician M. Keldysh

Academician Mstislav Keldysh, a prominent mathematician, mechanical engineer and computer expert, has been elected as president of the U.S.S.R. Academy of Sciences. He succeeds Alexander Nesmeyanov, who has resigned at his own request, pointing out that he had held this administrative office for more than ten years. Nesmeyanov himself nominated Keldysh as his successor. Academician Keldysh graduated from the physics and mathematics faculty of the University of Moscow in 1931 at the age of twenty and won his doctorate in 1938. He worked for several years in the Central Institute of Aerodynamics. Theories he elaborated have led to effective methods of eliminating 'flutter' in wings and tail units of aircraft. His theories also resulted in new designs for hydro-foil ships. From 1932 he was first a reader, and later a professor, in the Moscow State University. In 1943 he became a corresponding member of the Academy of Sciences and in 1946

was elected a full member. In 1960 he became a vice-president of the Academy. In mathematics, Academician Keldysh has made major contributions to the development of the calculus, to computing techniques and to various aspects of automatic remote control.

Physics at Sheffield : Dr. R. A. Smith, C.B.E.

Dr. R. A. Smith, who has been appointed to the chair of physics at Sheffield in succession to Prof. W. Sucksmith, is at present head of the Physics Department, Royal Radar Establishment, Malvern. After graduating with first-class honours in mathematics and natural philosophy at Edinburgh in 1930 and with first-class honours in mathematics at Cambridge in 1932, he did research work in the Cavendish Laboratory for which he received the degree of doctor of philosophy in 1936. From then until he became lecturer in physics at the University of Reading in 1939 he was Carnegie Research Fellow in the University of St. Andrews. In 1939 he was invited to join the Telecommunications Research Establishment, becoming head of the Physics Department in 1945. The research programme of the Physics Department at Malvern covers a wide field including semi-conductor physics, low-temperature physics, infra-red spectroscopy, microwave physics, electronics and plasma physics. It includes a theoretical physics group and a mathematical group, the latter being specially interested in electronic digital computation. Dr. Smith has written a number of papers and books including *Radio Aids to Navigation* and *The Wave-mechanics of Crystalline Solids*. He was made C.B.E. in 1960. Dr. Smith's appointment as professor of physics will date from October 1, 1961, and he will succeed Prof. Sucksmith as head of the Physics Department when the latter retires in September 1962.

Director of the British Industrial Biological Research Association : Dr. Leon Golberg

Dr. Leon Golberg has been appointed director of the recently formed British Industrial Biological Research Association (see *Nature*, **188**, 1072; 1960). Dr. Golberg is at present medical research director of Benger Laboratories, Ltd., and it is expected that he will take up his appointment with the Association towards the end of the year. Born in Cyprus, Dr. Golberg was educated in South Africa, where he graduated in 1935 with honours in organic chemistry at the University of Witwatersrand. The following year he gained an M.Sc. in physical chemistry. He then came to the United Kingdom and for two years was a member of Sir Robert Robinson's research team at Oxford, carrying out investigations in organic chemistry. In May 1939 he returned to the University of Witwatersrand, and he remained in South Africa throughout the Second World War, working on a variety of nutritional problems at the biochemical laboratory (which he himself established) of the Union Defence Force at the South African Institute for Medical Research. After the War he returned to the United Kingdom and spent six years studying medicine at Emmanuel College, Cambridge, University College Hospital Medical School, London, and Addenbrooke's Hospital, Cambridge. After qualifying in 1951, he became senior lecturer in chemical pathology at the University of Manchester, and in 1955 medical research director of Benger Laboratories, Ltd.

Research Reactors for Universities and Technical Colleges

In reply to a question in the House of Commons on May 9, Mr. D. Freeth, the Parliamentary Secretary for Science, said that the Government had approved in principle the provision of three nuclear reactors which would be available to universities and colleges of technology for teaching and research. One would be sited in Scotland and one in Lancashire, and it was proposed to site the third in the London area, where it would be available to the Imperial College of Science and Technology, and other institutions in London. Mr. Freeth was advised that the Atomic Energy Authority was not at present developing small and medium reactors, but was undertaking research in many fields which would be applicable both to small and large reactors. In a written answer on May 9, Mr. Freeth said that the Atomic Energy Authority planned to concentrate at Culham all its work on plasma physics and controlled thermonuclear reactions. The site was being developed in three stages, of which the first, including a large experimental hall, should be completed early in 1962, while the second stage, to be developed by mid-1963, included further provision of laboratories and a lecture theatre.

U.K. and U.S.S.R. Collaboration on Peaceful Uses of Atomic Energy

A formal agreement providing collaboration on the peaceful uses of atomic energy between the U.S.S.R. State Committee of the Council of Ministers for the Utilization of Atomic Energy and the United Kingdom Atomic Energy Authority was drawn up, following a meeting of representatives of the two bodies, held at the headquarters of the Authority in London during May 15–16. Among the representatives, and signing the agreement on behalf of the two bodies, were Prof. V. S. Emelyanov, chairman of the State Committee, and Sir Roger Makins, chairman of the Authority. Under this agreement, the bodies concerned will organize conferences and visits to facilities in their respective countries by comparable groups of specialists from the other country; normally, these will last for periods of 1–2 weeks, and provide for visiting groups of 4–8 specialists. The Authority and State Committee will undertake reciprocal exchanges of unclassified reports concerned with the peaceful uses of atomic energy. Information of commercial value will be exchanged only at such times and on such commercial terms as may be agreed in each case. It is hoped that this agreement will enable the interchange of new scientific instruments and equipment, including radioisotopes and apparatus designed for their application in medicine, biological research and industry. The agreement will remain in force for a period of five years. Among the fields of collaboration envisaged in the agreement are: nuclear physics; solid-state physics; basic radiation chemistry; inorganic chemistry of elements of importance in nuclear science and technology; research on isotopes and research on the application of isotopes; plasma physics; high-energy physics; reactor physics; experimental fast reactors.

Conservation of Wild Life

A recent issue of *The Bulletin of the International Union for Conservation of Nature and Natural Resources* (**9**, No. 7, 3; 1960) outlines the efforts being made in various countries, especially Thailand and the

Netherlands, to promote the objectives of nature conservation. In Thailand the game law is being revised according to the experience of game laws in other countries, and the forest law, too, is also being examined since it is ineffective in preventing destruction; setting aside of the primitive regions as natural reserves and national parks is also under consideration. In the national budget of the Netherlands for 1961 a sum of about 2·2 million dollars has been earmarked for nature protection (as compared with the sum of 1·2 million dollars for 1959). 1·3 million dollars is intended for the purchase of reserves and 300,000 dollars for their management, figures which compare with 630,000 dollars and 210,000 dollars respectively for 1959. In addition, the personnel of the Institute of Ecological Research for Nature Protection has been increased from 16, in 1959, to 21.

The City Museum, Sheffield

THE combined annual reports of the City Museum, Sheffield, for the two years 1958–60 form an inspiring record of progress and initiative by a relatively small staff (Pp. 20+4 plates. Sheffield: City Museum, 1961). The theme of service to the community underlies the work of this Museum. Prominent among its activities is that of evening opening in the summer until 8.30 p.m. and the organization of more than a hundred demonstrators at the Unesco exhibition, "The Earth as a Planet". New displays include Saxon jewellery and metal-work, medieval pottery and sculpture, British bats, and one illustrating the variety and forms in extinct animals.

South African Prehistory

THE January and February issues of the *South African Journal of Science* contain articles of considerable interest to archæologists. R. J. Mason discusses the problem of the earliest tool-makers in South Africa. P. V. Tobias brings forward new evidence and new views on the evolution of man, and Gordon Cramb continues his report on the excavations undertaken at the Holley shelter near Wartburg, Natal—the first report appeared in the same journal as long ago as 1952. Mason's conclusions are certainly very interesting in view of the human finds of very early date in the region. He says that up to now in South Africa there is no evidence for stone tool-making earlier than the complex earlier Acheulean stage, which is possibly equivalent to Olduvai Gorge Bed 2. There seems to be evidence at the limeworks site for the use of bone for tool-making purposes at an earlier date, but at present no stone implements have been found with them. Tobias does not agree with Dr. Wells, who has suggested that the basic human type in South Africa was possibly proto-sapiens. He claims that an early proto-sapiens such as that found at Kanam in Kenya is not early Pleistocene but Middle Pleistocene in date. He argues that the 'Rhodesioids' are derived from the African Middle Pleistocene hominids, and, in turn, these later gave rise to the Boskopoid and Bush types. Tobias also discusses the roles of cultural and natural selection in South African human evolution. A very extensive bibliography is appended. The Holley rock-shelter site has yielded artefacts belonging to the later Stone Ages from the upper layers. Below them a series of Middle Stone Age tools has been unearthed. From both these levels carbon samples were collected and these were analysed at the British Museum. The results would seem to be: 18-in.–24-in. layer 4,490 years ± 150 years, and 24-in.–30-in. layer 18,200 years ± 500 years.

Instrumentation in Industry

As a means of increasing the application of scientific method to industry, the Department of Scientific and Industrial Research has produced another of its popular booklets. This one, *Instruments in the Factory*, has been written by Dr. J. Thomson, director of the British Scientific Instrument Research Association, and shows that, despite the increasing use of instruments in modern manufacturing processes, there is still scope for improving instrumentation in most industries (Pp. 12. London: Department of Scientific and Industrial Research, 1961). Thermostatic control of water temperature is an example of how instrumentation can be extended. The smoke detector is another; its usefulness is easy to recognize, and the absence of smoke is a good indication of the efficient use of fuel. Another example occurs in flow measurement: often, particularly in smaller firms, accurate measurement of the flow of liquids in manufacturing processes can save a large amount of money. Simple robust methods are available. In the same way the 'thickness' of a liquid can also be measured with advantage. Manufacturers who would like to pass from 'instrumentation' to 'automation' will find from a study of this booklet that automatic control can often take very simple forms; instrumentation and automation can be used to improve products.

Hyperon Stars

THE extension of V. A. Ambartzumian's hypothesis of stellar evolution led G. S. Saakyan (*Priroda*, 11, 14; 1960) to develop a new hypothesis of stellar evolution based on the findings of certain recent discoveries of now elementary particles. According to this hypothesis dense stars of the type of 'white dwarfs' on further contraction become neutron stars. During this process their density changes from approximately 10^4 gm./cm.^{3} to about 10^8 gm./cm.^{3}. With a further increase of density to 10^{15} gm./cm.^{3} these stars become hyperon stars representing a more stable state under such conditions. The mass of such hyperon stars in equilibrium is approximately the same as that of the Sun, while the size of their radius is of the order of a few kilometres. Only the central part of such stars contains hyperons. The outer zone is made of neutrons, while the outermost part is made of bare nuclei and electrons. The enormous pressure inside such stars is balanced by the force of gravity, but when such an equilibrium is disturbed hyperon stars are liable to explode with a terrific violence, not unlike the explosions leading to the formation of the 'nova' stars.

Scientific Information Notes

Scientific Information Notes for February–March 1961, issued by the National Science Foundation, notes that the Foundation is supporting a two-year investigation of the line-formula notation for representing chemical structural formulæ as linear arrays of symbols. This is part of an extensive study of chemical notation systems. The Foundation is continuing to support the Harvard University project for research on automatic translations and mathematical linguistics. It is also giving partial support to the abstracting office of the International Federation for Docu-

mentation, which is developing a world inventory of scientific abstracting services, and establishing an international clearing house for information on abstracting services and techniques. The Federation has also recommended the formation of a Group on Mechanical Storage and Retrieval; the Ford Foundation has announced a grant of 8 million dollars to the Council on Library Resources, Inc., for continued research to improve library methods, with emphasis on ways of storing and finding information in the library of the future.

Peasant Agriculture in the Tropics

A VALUABLE review of different systems of peasant agriculture in various parts of the tropics is made by E. W. Momber, School of Agriculture, University of Cambridge, in a recent issue of *Rural Life* (6, No. 1; 1961). Momber analyses existing practices in Northern Rhodesia, Tanganyika and Nigeria and shows that nearly all peasant systems were evolved to carry a subsistence economy where there was plenty of land and few people, and that the traditional systems of peasant agriculture are not basically unsound for the purpose for which they were designed. To-day they are being asked to perform tasks which they were not designed to carry out.

Sheep Husbandry in Northern Ireland

A FEATURE of farming in Northern Ireland during recent years has been, says the Ministry of Agriculture of Northern Ireland (Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 47: Sheep Husbandry. Pp. 26. Belfast: Ministry of Agriculture, 1961), an increase of the number of sheep reared from 654,000 in 1945 to 1,097,000 in 1960. Important factors in this development have been the improvement in pasture manuring and management and the relatively high cost of store cattle. The leaflet discusses breeds of sheep, the types and sizes of sheep flocks, the mating, management and diseases of sheep and the handling and care of wool. It is written in clear, non-technical language and is certainly a very good exchange for a postcard sent to Belfast.

Damage to Maize in Nigeria

EXAMINATION of samples of maize obtained from market traders at Ibadan, Nigeria, over a period of fourteen months by G. H. Caswell of the Department of Agriculture, University College, Ibadan, Nigeria, showed that damage to maize by *Calandra oryzae*, L., the only important pest of stored maize in this region, is slight compared with damage by the same insect in other countries (*J. West Africa Sci. Assoc.*, 6, No. 1, February 1961). This is probably due to the fact that farmers use a system of shifting agriculture, and store maize on their farms where *Calandra* is not endemic. Should the practice of central storage become more common, damage is likely to increase.

The Institution of Metallurgists

AT the seventeenth annual general meeting of the Institution, held in London on May 17, Dr. N. P. Allen, superintendent of the Metallurgy Division, National Physical Laboratory, was elected president for the year 1961–62, in succession to Mr. W. E. Bardgett. The following elections were also made: *Senior Vice-President*, Dr. E. G. West, technical director, Aluminium Development Association; *Vice-Presidents*, F. Dickinson, director and general manager of the Development and Research Department, International Nickel Co. (Mond), Ltd., and Dr. L. Northcott, principal superintendent, Materials Division, Armament Research and Development Establishment, Fort Halstead (War Office); *Honorary Treasurer*, L. W. Derry, head of the Metallurgy Department, Battersea College of Technology; *Members of Council*, H. Morrogh, director, British Cast Iron Research Association, Alvechurch, Birmingham, S. S. Smith, research manager, Imperial Chemical Industries, Ltd., Metals Division, Kynoch Works, Witton, Birmingham, and Dr. J. C. Wright, reader in Industrial Metallurgy, Birmingham College of Advanced Technology.

The Linnean Society of London

AT the anniversary meeting of the Linnean Society of London, held on May 24, the following were elected officers for the session 1961–62: *President*, Prof. Thomas Maxwell Harris; *Treasurer*, the Earl of Cranbrook; *Secretaries*, Dr. C. R. Metcalfe (Botany), Dr. H. G. Vevers (Zoology), Dr. John Smart (Editorial); *Vice-Presidents* appointed were: Prof. A. R. Clapham, Prof. C. F. A. Pantin, the Earl of Cranbrook and Dr. W. T. Stearn. *New Members of Council* elected: Mr. P. R. Bell, Mr. J. B. Gillett, Prof. Tom Harris, Dr. D. M. Kermack and Dr. Sydney Smith. *Linnean Gold Medals* were presented to Mr. Edmund William Mason and Dr. Frederick Stratten Russell. Dr. Mary Agnes Chase, of the United States, and Dr. Franz Petrak, of Austria, were elected foreign members.

The H. G. Wells Society

THE H. G. Wells Society has recently been founded to promote and encourage an active interest in, and an appreciation of, the life and work of one who made such great contributions in many directions during the first half of this century. Educated as a scientist, he inspired persons of all persuasions to take nothing for granted and to examine fundamental principles in all activities, particularly Government, history, planning, possibilities of science and its potential assistance to mankind. The new Society is non-political and non-sectarian, and seeks only to find that which is good in the thought, word and deed of a great man and which can be used as a memorial to one who filled a great gap in human thought. Further information can be obtained from the hon. secretary, Mr. J. R. Hammond, 39 Rugby Road, West Bridgford, Nottingham.

The Royal College of Surgeons of England

A GRANT of £250,000 has been made to the Royal College of Surgeons of England by the Wolfson Foundation. The gift will be applied primarily to the provision, furnishing and equipment of the Hunterian Museum. The Museum—now being rebuilt following its destruction by bombing—is expected to be finished by the spring of 1962, and is to house the collection of anatomical and pathological specimens collected by John Hunter and purchased by the Government of the day, after his death in 1793.

College of Advanced Technology, Birmingham

IN support of the College policy to promote and develop research activities, Messrs. Joseph Lucas, Ltd., Birmingham, have established a fellowship, to be known as the Joseph Lucas research fellowship, in production engineering which will be tenable normally for a period of two years with provision for extension to three years, and valued at £1,300–£1,500 per annum.

University News : Cambridge

THE following appointments of overseas fellowships at Churchill College have been made: Prof. A. Schlüter of the Max Planck Institute, Munich, during March–September, 1961; Prof. G. Fodor of the Hungarian Academy of Sciences during April–July, 1961.

Leeds

THE following appointments have been announced: Dr. A. E. Guile as senior lecturer, and J. M. Stephenson as lecturer, in the Department of Electrical Engineering; Dr. D. H. Niblett as lecturer in the Department of Physics; Dr. T. A. Scott as lecturer in the Department of Biochemistry; D. J. Harberd as lecturer in the Agricultural Section of the Department of Agriculture.

Liverpool

THE following appointments have been announced. *Readerships:* Dr. R. S. Benson (mechanical engineering); J. O. L. King (animal husbandry); Dr. J. H. Leck (electronic engineering); Dr. R. B. Whittington (civil engineering); Dr. A. Young (numerical analysis). *Senior Lecturers:* J. W. Dransfield (veterinary anatomy); Dr. W. H. Evans (physics); Dr. D. Flinn (geology); J. Halling (mechanical engineering); Dr. D. Hull (metallurgy); Dr. J. W. Lynn (electric power engineering); Dr. W. R. H. F. Muirhead (physics); Dr. N. Rast (geology); Dr. J. P. Riley (oceanography); Dr. C. F. H. Tipper (inorganic and physical chemistry); Dr. H. Wilson (pharmacology).

London

DR. M. G. FLEMING, reader in mineral technology in the Imperial College of Science and Technology, has been appointed to the University chair of mineral technology tenable at that College. Dr. O. J. Lewis, senior lecturer at St. Bartholomew's Hospital Medical College, has been appointed to the University readership in anatomy tenable at that College. Dr. R. F. Strickland-Constable, senior lecturer at the Imperial College of Science and Technology, has been appointed to the University readership in chemical engineering tenable at that College.

Titles have been conferred on the following: Dr. Alexander Lawson (professor of organic chemistry), in respect of his post at the Royal Free Hospital School of Medicine; Mr. Ralph Shackman (professor of urology), in respect of his post at the Postgraduate Medical School of London; Dr. E. G. C. Clarke (reader in chemistry), in respect of his post at the Royal Veterinary College.

Announcements

MR. L. A. THOMAS has been appointed chief physicist at the Hirst Research Centre of The General Electric Co., Ltd., Wembley, Middlesex. He will be a member of the staff of the Central Research Laboratories with special interest in the programmes of long-term and fundamental research. He was appointed head of the Materials and Components Division in 1960 and retains his responsibilities in this field of the work of the Centre.

THE annual general meeting of the Royal Society of Tropical Medicine and Hygiene will be held in Manson House, 26 Portland Place, London, W.1, on June 15 at 7.30 p.m. The new president, Sir George McRobert, will be inducted in succession to Sir William MacArthur. The Chalmers Medal will be presented to Dr. C. E. Gordon Smith.

THE third International Congress on Catalysis is to be held in Amsterdam during July 20–25, 1964. The theme of the Congress will be "The Mechanism of Heterogeneous Catalysis". Further information can be obtained from Dr. D. M. Brouwer, c/o Badhuisweg 3, P.O. Box 3003, Amsterdam-N, Netherlands.

THE sixth International Hæmatology Symposium will be held at the State Agricultural College, University of Ghent, during July 24–28. Further details can be obtained from Prof. J. Van den Brande, Rijkslandbouwhogeschool, Coupure Links, 235, Ghent (Belgium).

THE annual general meeting of the Freshwater Biological Association will be held in the meeting room of the Zoological Society of London, Regent's Park, London, N.W.1, on June 20. Further information can be obtained from the Director, Freshwater Biological Association, Windermere Laboratory, The Ferry House, Far Sawrey, Ambleside, Westmorland.

THE British National Committee for Physics is organizing a conference on "Optical Instruments and Techniques", under the auspices of the International Commission for Optics, in London during July 10–14. Further information can be obtained from Mr. K. J. Habell, National Physical Laboratory, Teddington, Middlesex.

THE Building Research Station of the Department of Scientific and Industrial Research is holding open days for the new Materials Laboratory during July 10–13. Further information can be obtained from the Director, Building Research Station, Bucknalls Lane, Garston, Watford, Herts.

THE Institute of Physics and the Physical Society is organizing a conference on "Thermoelectricity" at Durham Colleges, University of Durham, during July 10–12. Among the topics to be considered are: basic properties of thermoelectric materials, solid and liquid; methods of determining electrical conductivity, thermal conductivity, and thermoelectric power; properties of materials, problems and techniques associated with device developments; thermoelectric devices and their applications. Further information can be obtained from Prof. D. A. Wright, Department of Applied Physics, Durham Colleges, Durham.

THE B.B.C. and the Council for Nature announce that they are organizing a competition for amateur cine-photographers for natural history films suitable for showing on television (35 mm. and 16 mm. at 24 frames per sec.). The closing date is February 28, 1963. Further information can be obtained from the Council for Nature, 41 Queen's Gate, London, S.W.7.

THE Trustees of the Plastics Industry Education Fund invite, from young people working in the plastics industry, applications for a limited number of training grants towards the cost of full-time study on an approved course leading to a degree or diploma in science, technology or industrial design. Applications must be submitted to the Secretary, Plastics Industry Education Fund, 6 Mandeville Place, London, W.1, by July 15.

THE article entitled "Measuring Indigestion", which appeared in the May 13 issue of *Nature* (p. 596), refers to an original paper appearing in *Research in Industry*, published by Stanford University.

UNIVERSITY COLLEGE OF SWANSEA

NEW CHEMISTRY LABORATORIES

NEW chemistry laboratories were opened at University College, Swansea, on May 1 by Sir Alexander Todd. When, in 1920, a department of chemistry was established by J. E. Coates in Swansea, accommodation was provided in temporary buildings the useful life of which was expected to be ten years. In fact, the Chemistry Department has occupied this accommodation until this year, when the new laboratories became available.

The building consists of three major units: a north wing with teaching laboratories; a south wing with research laboratories; and a central spine which contains the lecture theatres, main stores and central services. Accommodation is on three floors, with a total area of 66,000 sq. ft.

The three floors of the teaching wing are essentially the same. Each consists of one general and one honours laboratory accommodating 60 and 48 students respectively, and built on either side of common preparation and balance rooms. The ground-floor honours laboratory has special facilities for organic chemistry; the first and second floor honours laboratories are specially designed for physical and inorganic chemistry respectively. In the general laboratories, each working space is provided with two sets of lockers so that a total of 360 elementary students can be accommodated during one session.

The research wing contains principally staff rooms and research laboratories. The ground-floor is devoted to organic chemistry and has six staff rooms facing south and two six-man research laboratories with an interconnecting service laboratory facing north. The arrangements on the first floor (physical chemistry) and the second floor (inorganic chemistry) are similar. This wing also contains professors' suites, a departmental library with book-stack, microfilm room and reading room, and a seminar room.

There are a number of general facilities for both teaching and research in the central spine. These include two lecture theatres, both stepped, windowless and mechanically ventilated, with seating for 320 students in the larger theatre and 105 students in the smaller one; at second-floor level above the large lecture theatre is a combined lecture theatre and examination room seating 120 students; there are three main stores directly above each other in the central spine and connected by a goods lift. In addition, in the central spine, there is an engineering workshop, an instrument room and separate workshops for glass-blowing and for electronics. A semi-technical area is situated under the small lecture theatre and is equipped for operations such as fractionation and solvent extraction on a pilot plant scale. A number of rooms with special facilities open off the semi-technical area: a cold room; a walk-in fume cupboard; a fire and flood laboratory; a centrifuge room and a constant-temperature room. The first floor of the central spine included a microchemistry laboratory, dark rooms and special laboratories for infra-red and Raman spectroscopy. On the second floor are a radio chemistry laboratory, special instrumentation rooms and a liquid-air plant.

Benches in the laboratories have been designed to give flexibility and ease of access to services for

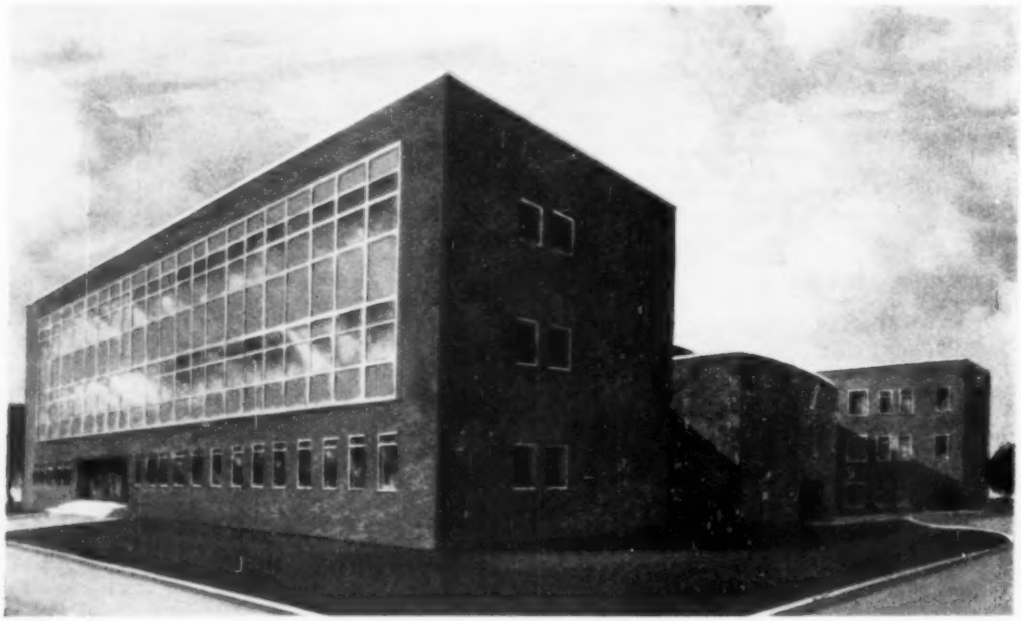


Fig. 1. New Chemistry Laboratories, University College of Swansea

maintenance. Most of the benches, both of the island and wall type, have tops supported by cantilever brackets which fit into specially designed service stands fixed to the walls and floor. Underbench cupboard and drawer units then slide into a position below the bench tops and conceal the service racks. In the research laboratories the tops can be fixed at either standing or sitting height, or can be removed entirely leaving only the stands and associated services. The service racks are formed by a number of metal supports spaced at approximately 3-ft. centres and connected at bench-level by a 9-in. wide horizontal teak strip and a 6-in. deep teak fascia. Curved brackets are fixed to the metal strands which support the service pipes, from which outlets are taken at suitable positions. Where a concentration of service is required, plumbing has been simplified by the use of service towers, which results in a clear bench top and a generally neater appearance. In the physical chemistry research laboratories the bench tops and cupboards form movable integral units. All services are available along the walls, with electrical services also available from ceiling outlets. This gives great flexibility in the arrangement of the laboratories.

Bench tops are of Burma teak (*Tectona grandis*); all other exposed timber and veneers are of West African mahogany. Teak has also been used throughout as flooring in laboratories. Reagent shelves have been covered with white 'Vitrolite' and the working tops of fume cupboards formed from a sheet of armour-plated glass.

The number of students taking courses in chemistry now exceeds 250, including 37 honours students and 26 research students and fellows. These numbers are expected to increase considerably in the next five years, during which period the College is planning to increase the number of students from 1,500 to 3,000.

The new facilities make possible very substantial expansion of the research programme in Swansea. As it is, the work of the Department covers a wide range of interest. There is a group working with D. A. Long in the field of molecular spectroscopy with special emphasis on Raman studies. Other groups are concerned with the infra-red spectroscopy of amides (H. E. Hallam *et al.*), the kinetics of nitrosation reactions (G. Stedman *et al.*) and solid-state chemistry (K. J. Gallagher *et al.*). The organic chemists are largely concerned with natural products. This work, which is under the general direction of Prof. C. H. Hassall and Dr. R. F. Curtis, involves work on peptides, cardenolides and alkaloids. A major investigation, dealing with the pathways of biosynthesis of complex phenolic compounds, combines techniques of organic chemistry with others drawn from the relatively young field of chemical genetics. There are also investigations in the field of steroid chemistry (G. H. R. Summers *et al.*) with particular emphasis on reaction mechanisms.

SCIENCE AND INDUSTRY—THE PROBLEM OF COMMUNICATION

A CONFERENCE, organized by the Department of Scientific and Industrial Research and held in Swansea during April 18–19, had as its primary object the critical examination of present-day methods of disseminating scientific and technical knowledge. Both the papers and the lively discussions which followed indicated the growing concern in scientific and industrial circles with the many-sided nature of this problem.

Opening the conference, Lord Brecon, Minister of State for Welsh Affairs, emphasized the relation between the growth of scientific knowledge, the resultant industrial innovation and the growth of industry. His reference to the time-lag between technical advance and industrial use of new techniques and new materials was echoed by several speakers.

Nine papers were briefly presented to enable delegates themselves to participate in the frank and critical appraisal of the problems and solutions as presented. The first paper, by W. S. Robertson, chief executive of the Scottish Council for Development and Industry, reminded delegates that as the volume of available information multiplied there was a proportionate increase in the difficulty of condensing and making that information effectively available to those who could use it. The answer to the increasing volume of literature, it was suggested, might lie in the development of mechanized recording and retrieval systems, but Mr. Robertson maintained that there was still nothing quite so effective as personal contact for passing on new ideas and know-how. He thought that scientific and technical, as well as commercial, people should be encouraged to travel more widely and more frequently, and he condemned the inhibiting parochial attitude of many firms which restricted the development of this most useful means of exchanging ideas.

Dr. D. J. Urquhart, director of the National Lending Library for Science and Technology, also emphasized personal contact, and likened the seeker after scientific information to the stranger in a vast, growing, changing city, the maps of which became out of date almost as soon as they were published. The best and almost only way of reaching an objective quickly was to ask other people working in the specified field. Dr. Urquhart stressed the assistance that libraries and information scientists could provide in making these contacts and warned the conference that existing facilities were inadequate. Quoting Wales as an example, he pointed out that there were only two public libraries with a reasonable holding of scientific periodical literature. The educational aspects of the problem were discussed in the paper by Dr. M. R. Hopkins, senior lecturer in physics at Swansea. He criticized the attitude of narrow utilitarianism which leads to a programme of teaching preoccupied with its immediate purpose. He suggested that the training of every educated man and woman should include some teaching of the fundamental principles of scientific thought, and that both scientists and non-scientists should be educated in the basic skills of communication. Speakers from both platform and floor supported this view; it was pointed out that not one university department specializing in documentation studies existed in Britain. A large increase in the British research effort in this field and the allied one of information retrieval was called for. Following Dr. Hopkins several speakers demanded better facilities for

documentation research and indicated how poorly this field was supported in Britain. Dr. R. M. Lodge, research manager of British Nylon Spinners, Ltd., spoke on the communication network in an industrial organization and indicated the difficulties of presenting technical information at many different levels within the firm.

The mass media of communication—press, radio, television, films, exhibitions and conferences—were each dealt with in turn by acknowledged experts. It was generally accepted that the primary value of radio, television and films was in creating a healthy climate of opinion to encourage scientific and technical development. Dr. T. Margerison, science editor of the *Sunday Times*, felt that more use could be made of television by the inclusion of news reports of scientific and industrial developments in magazine-type programmes, and the possibility of implanting the germ of an idea in this way should not be overlooked. Mr. P. Cudlipp, editor of the *New Scientist*, reviewing the function of the general science journal, stressed the value of scientists and technologists keeping themselves broadly informed on a wide range of scientific disciplines. He referred also to the need for scientists themselves to take a hand in the preparation of material that the layman could understand, and noted the growing number of science correspondents in the popular press—which was a recognition of the public interest in science. A better balance and more careful reporting of science news had been achieved, but there was still room for improvement. Exhibitions and conferences were dealt with by Mr. E. H. Underwood, the director of public relations for the U.K. Atomic Energy Authority, who stressed the importance of defining objectives and the audience aimed at, but once again, however, personal contact was cited as being very often the most valuable result of attending such functions. Mr. E. Anstey, of the British Transport Commission, and president of the Scientific Film Association, spoke on "Films to Illuminate and Persuade", directing attention to the use of film as a tool not only for spreading scientific knowledge but also for the popular understanding of science.

In a paper by Mr. L. W. Stevens-Wilson, head of the Steel Users Section, British Iron and Steel Research Association, attention was directed to the need for closer collaboration between specialist or vertically oriented technical information services and horizontal or regionally based services. The Department of Scientific and Industrial Research was strongly recommended to set up more branch offices, similar to those existing in Cardiff and Edinburgh.

The widely differing views of delegates and the relative value of the different methods of communicating information made it clear that there is no one ideal solution to the problem. It would appear that there is still need to strengthen all existing techniques. There was general agreement that in many sectors of industry the prevailing level of interest in research and development was not very high, and that the outstanding difficulty was not simply to improve the means of transmitting scientific and technical information but to stimulate interest at the receiving end in industry. How this was to be achieved remained largely an open question, but it must involve a strong element of personal contact to make an effective change in the habits of thought and climate of opinion in both industry and science.

E. E. Williams

AN INTERNATIONAL ANDEAN YEAR

On the initiative of Unesco and by invitation of Dr. Angel Establier, head of the Scientific Office in Montevideo of that Organization in Latin America, who has been interested in such a project from its beginning, a meeting was held in Buenos Aires, during April 3–4, to discuss the planning of an International Andean Year. During such a programme, an intensive study would be carried out on the range of mountains known as the Cordillera de los Andes, from Panama to the southern part of the continent. A small number of scientists from different countries interested were present: Dr. H. O'Reilly Sternberg (Brazil); Dr. Guillermo Mann (Chile); Dr. Tobías Lasser (Venezuela); Dr. Ovidio Suarez (Bolivia); Eng. Eduardo Baglietto, General M. Olascoaga and Drs. F. Bonorino Udaondo, J. Roederer, Angel Cabrera, M. Sadosky, B. A. Houssay and V. Deulofeu, all from Argentina. Dr. A. Hurtado, from Peru, unfortunately could not attend. Dr. A. Establier represented Unesco and his office will be the centre for the various groups in preparing the project.

After an introductory welcome by the vice-dean of the Faculty of Exact and Natural Sciences at Buenos Aires, Dr. M. Sadosky, Dr. Venancio Deulofeu was elected chairman and Dr. Establier acted as advisory secretary. Four sessions were held.

All present agreed in considering that the project to institute an International Andean Year will be of great importance not only because of its width of interest and of the scientific results which are likely to accrue, but also because of the number of scientists involved and the expected international participation from countries outside South America. It was also considered that a project of this magnitude will have a favourable impact on the progress of science and the future scientific development of most of the South American countries.

Discussions dealt with the fields which it would be desirable to cover during the International Andean Year. As a preliminary list it was considered possible and convenient to work on the following subjects: 1, geology; 2, botany; 3, geophysics; 4, human biology; 5, zoology; 6, human ecology; 7, geomorphology including glaciology; 8, physics of high altitudes; 9, soil sciences; 10, geography; 11, agronomic sciences (in collaboration with the Food and Agriculture Organization); 12, sociology; 13, ethnography (both 12 and 13 in collaboration with institutes of social sciences); 14, archæology; 15, anthropology; 16, economics (in collaboration with the Comisión Económica para América Latina).

In each of these fields some subdivisions have already been made and, as an example of the type of work which would be involved, some specific projects were mentioned. For example, it was suggested that in studying the geology of the Andes, it would be desirable to concentrate the efforts in examining the evolution of the Andean range, especially the tectonic

and magmatic cycles of the Andean syncline, tertiary and quaternary vulcanism and the magmatic provinces in the Andes.

A further meeting is being planned for December 1961, and will be held in Santiago de Chile, to consider reports to be presented by the scientists participating in the meeting in Buenos Aires and to elaborate further and develop the specific projects in each scientific field.

In the meantime, the Unesco Scientific Office in Montevideo will start compiling a bibliography of research done on the Andes, and collecting the names of scientists who have been active in that field, or who, by their training, are likely to be interested in participating in any of the activities planned for the International Andean Year.

Further information on this project can be obtained from Dr. A. Establier, Centro de Cooperación Científica de la Unesco para América Latina, Boulevard Artigas 1320, Montevideo, Uruguay.

V. DEULOFEU

SOLAR VARIATIONS, CLIMATIC CHANGE AND RELATED GEOPHYSICAL PROBLEMS

UNDER the above title, a symposium was arranged by the New York Academy of Sciences, through the Academy's Section of Geological Sciences and its Division of Oceanography and Meteorology, in co-operation with the American Meteorological Society. The meetings were held in New York during January 24–28. The papers given at the symposium are to be published by the Academy in a forthcoming volume of its *Annals*.

Understandably, the United States provided about four-fifths of the sixty or so participants who offered papers or contributed to the discussions, but a number of workers active in the fields covered by the symposium were present from Canada, the United Kingdom, Holland, Germany and Hungary. Swedish, Russian and Australian contributions had been invited, but their authors were unable to be present. Abstracts of the papers were provided and the meeting as a whole was admirably organized. The generous hospitality of the New York Academy of Sciences was indeed a feature.

The organization of the conference and the arrangements for overseas visitors were largely in the hands of Dr. Rhodes W. Fairbridge, professor of geology at Columbia University, to whom indeed a great part of the success of the meeting was due. Dr. Fairbridge's arguments for the relationship of changes of sea-level, great and small, to the fluctuations of climate which have affected and continue to affect the volume of the Earth's ice-sheets and glaciers, have become widely known (cf. his recent article in *Scientific American*, 202, No. 5, 70; 1960). A fuller statement has now been published in *Physics and Chemistry of the Earth*, 4 (Pergamon Press, 1961). Developing as they do from his earlier work on the eustatic changes shown on the coast of West Australia, they integrate a vast amount of carefully assembled field evidence on a world-wide scale and, cautiously yet persuasively presented, they will be found acceptable by many workers. Nevertheless, it can be agreed that we do not yet know enough about the other agencies that may have affected the volume of the hollows in which the oceans lie.

Climatic change is demonstrably a subject with exceptional ramifications, and the contributions of a great many scientists from differing disciplines are repeatedly called for. Accordingly, the scope of the symposium was enormously wide, beginning with six papers on solar physics under the chairmanship of Dr. Donald H. Menzel (Harvard University). Climatic effects potentially attributable to solar variation were discussed under the chairmanship of Dr. Sigmund Fritz, replacing Dr. H. Wexler, who could not be present. It is evident that the only effects of solar variation that are so far generally accepted are those observable in the extreme ultra-violet end of the solar spectrum, affecting the high atmosphere and the Earth's magnetic field, although some of the apparent relationships with atmospheric circulation patterns are sufficiently suggestive to justify further attention. Among a variety of papers on various aspects of the radiation balance and the general circulation, H. H. Lamb (Meteorological Office, Harrow) presented some of his recent work on displacements of the circulation pattern (cf. *Geografiska Annaler*, 1960). A further session was devoted to meteorological satellites. Dr. Helmut E. Landsberg (United States Weather Bureau) took the chair at a session entitled "Glaciology, Oceanography and Climatology"; here Dr. William L. Donn presented a summary of the Ewing-Donn theory of the ocean control of Quaternary climate (*Science*, 1958), unfortunately with insufficient time for discussion of a controversial topic in which many would gladly have joined. A preceding paper by Dr. T. N. V. Karlstrom (Coast and Geodetic Survey, Washington) on the glacial history of Alaska provided evidence manifestly difficult to reconcile.

With Dr. R. F. Flint (Yale University) in the chair, followed by Dr. E. S. Deevey (Yale University), palæoclimatology came under review, including several papers around the theme of palynology. Dr. E. H. Willis (University of Cambridge) commented on some of the Fenland evidence. Among the most interesting contributions was that of Dr. Calvin Heusser (American Geographical Society), who gave evidence for the approximate contemporaneity of Late- and Post-Glacial events in the Rockies and the Southern Andes. With Prof. F. E. Zeuner (University of London) in the chair, a final session was devoted to papers around the theme of "Climatic Change and Man". Archæological studies in the United States and in the Near East were noteworthy; Dr. Ralph Solecki's discussion of some of the preliminary findings at the Shanidar cave in Northern Iraq was of great interest, and attracted attention.

It will be evident from this brief summary that a remarkable diversity of papers came up for discussion. Throughout the symposium the impression prevailed that there are many who are still hopeful that some kind of periodicity will appear, based on such solar manifestations as we can observe. From others, dispiriting criticisms equally abound. Dr. Reid Bryson (University of Wisconsin), for example, has applied modern statistical methods to the analysis of tree-ring spectra and found that the usual sunspot cycles fail to appear. On the other hand, several

contributors provided support for relationships between solar variations and the pattern taken by the general circulation.

It became abundantly clear how large a number of investigators are patiently accumulating evidence of the amplitude, character, effects and especially the dating of climatic fluctuations all over the world. Speculations regarding the causes abound; supporters of each of the popular theories—solar variation, atmospheric turbidity, carbon dioxide, ozone, variations in the Earth's orbital elements—find their several gods alternately set up and cast down. Workers in one field find themselves unable to judge the validity of the evidence from other disciplines; in this regard, the sessions and the informal discussion resulting from personal encounters between different kinds of specialists are for many a real help. A great deal of enjoyment is had by all, and those who are tempted to advocate simple explanations are repeatedly reminded of the complexity of the problems they so hopefully seek to solve. It now seems almost certain that no one simple panacea is in any way adequate to explain the intriguing patterns of climatic fluctuation to which the evidence points. Almost all the many processes involved seem likely to play some essential part, small or large. The forthcoming volume of papers will provide welcome reading.

GORDON MANLEY

EXPERIMENTAL TAXONOMY OF FLOWERING PLANTS

A SYMPOSIUM on the experimental taxonomy of flowering plants was held at the Linnean Society on March 3. The chair at the morning session was taken by the president, Prof. C. F. A. Pantin, and at the afternoon session by Dr. W. G. Templeman.

In a brief introduction, Prof. D. H. Valentine said that the symposium should provide a good illustration of both the coherence and the wide range of experimental taxonomy. In the papers to be heard, groups at all levels, from the local population to the genus, would be treated, and the problems would be approached from a variety of points of view—genetical, ecological and taxonomic.

Dr. A. D. Bradshaw, of the University College of North Wales, Bangor, then gave his paper on "Evolution within Plant Species in Relation to Soil Mineral Factors". He pointed out that while a considerable amount is known about evolution in relation to climatic and biotic factors, soil factors have, comparatively, been neglected. This is surprising, as an examination of the differences between closely related species shows that they often possess markedly different soil preferences, which indicates that soil factors must play an important part in evolution. Experiments have been done in sand cultures on a number of common species, especially *Festuca ovina* and *Trifolium repens*. The fescues used were all of the 28-chromosome type, and selected tillers were grown in a range of solutions with varying concentrations of calcium. Populations from chalk and peat soils showed a markedly different response to growth; and an experiment on samples from base-rich and base-poor soils from the Breckland showed a similar difference, although the populations were morphologically identical. *Trifolium repens* gave the same kind of response in relation to variation in both calcium and phosphate concentrations, but the phosphate and calcium responses were not parallel. It would appear that populations of both species are physiologically differentiated in relation to their mineral nutrition; and such differentiation cannot be neglected in considering the evolutionary processes in these and other common species.

In the discussion on this paper, it was pointed out that much information of a similar kind was available for cultivated plants, notably rice, but that a great deal of it was inaccessible or not widely known.

The second paper, on "Interspecific Hybridization as an Evolutionary Stimulus in *Œnothera*", was given by Dr. P. H. Raven, of the Rancho Santa Ana Botanic Garden, California. Dr. Raven first described *Œ. brevipes* and *Œ. clavaeformis*, a pair of annual species which occur in arid areas in western North America. The species differ in a number of morphological characters (habit, flower colour, etc.), in habitat, and also in their floral biology. In one, the flowers open at about sunrise, in the other, in the late afternoon, and they are pollinated by different but closely related species of bees, which are highly specific to these flowers. Geographically, the species have a rather broad area of overlap, and natural hybrids are sometimes formed (the species are occasionally visited by insects other than the bees mentioned above). Both species have 14 chromosomes; 7 bivalents are formed in most cells, though occasionally rings of 4 or 6 chromosomes are observed; fertility is high. In the hybrids the multivalents are more frequent, larger rings or chains of up to 12 chromosomes being recorded; fertility is low, and only 5–15 per cent of good pollen is formed. Although most of the hybrids between the particular pair of populations studied appeared to be F_1's, other populations can be found (taxonomically of subspecific status) which are probably of hybrid origin. It would appear that occasional hybridization of the kind described may well play an important part in increasing the number of evolutionary pathways available, especially in areas such as this, in which considerable climatic changes have been occurring. In general, it may be said that the retention of the ability to hybridize and to form stable recombinant phenotypes may be regarded as a significant part of the adaptive system in higher plants. There was a short but active discussion of this paper, in which the evolution of pollinating mechanisms and the part played by chromosome interchanges in the genus were discussed.

The final paper in the morning session was given by Dr. N. W. Simmonds, of the John Innes Institute, on "Classification and Nomenclature in Bananas and Potatoes". Dr. Simmonds dealt with bananas first. He pointed out that we now had a good knowledge of the probable course of evolution in the group. The cultivated bananas had arisen from the diploid species *Musa acuminata* and *M. balbisiana* as a result of polyploidy and hybridization, and consisted of a group of sterile, parthenocarpic clones, mainly triploid in constitution. In the potatoes, the cultivated plants probably originated from wild diploid species, as yet not certainly identified, which had developed into the cultivated tetraploid species *Solanum andigenum*; and this in turn, introduced into Europe as a small sample some four hundred years ago, had given rise

to *S. tuberosum*. This resembled the banana in being clonally propagated, but was unlike it in being sexually fertile. In both groups, it is practically impossible to apply the normal nomenclatural rules in any useful way. The banana now comprises six groups of sterile clonal cultivars which are not species in any reasonable meaning of the word; and to attempt to apply the Linnean names *M. paradisiaca* and *M. sapientum*, which represent two of these cultivars, would merely lead to confusion. In potatoes, many of the described species with Latin names refer to single clones, others to an arbitrary selection of plants from continuously varying populations; further difficulties arise in the identification of the Linnean type. In both groups, the best procedure is to discard the Latin nomenclature below the generic level, and apply the *Code for Cultivated Plants*. Rates of evolution in crop plants are high, and crops change; and this must be recognized by an appropriate flexibility of nomenclature. In the discussion, sympathy was expressed with Dr. Simmonds's view of the problem; nomenclatural divisions should resemble a neat fence rather than a barbed-wire entanglement.

In the first paper of the afternoon session, Dr. J. R. Ellis, of the Galton Laboratory, University College, London, spoke on "*Fragaria–Potentilla* Intergeneric Hybridization and Evolution in *Fragaria*". He first reviewed briefly the cytology and distribution of the genus *Fragaria*, and the preliminary experiments on hybridization in this group by Mangelsdorf and by J. K. Jones. Dr. Ellis then described in detail his own experiments, in which he used as seed parent both the garden strawberry, *Fragaria grandiflora* ($2n = 56$), and the artificial allopolyploid *F. vesca-grandiflora* ($2n = 70$). When *Potentilla erecta* ($2n = 28$) was used as pollen parent, hybrid seedlings were produced, but none survived to maturity; but with *P. fruticosa* ($2n = 14$) and *P. palustris* ($2n = 42$) as pollen parents not only did many hybrid seeds germinate but also a number of seedlings grew to maturity. There was great variation in the vigour of the hybrids, which were sterile, and all resembled their *Fragaria* more than their *Potentilla* parent; fertile amphiploids, which may be of value in strawberry breeding, have not yet been obtained. Studies of meiosis in the hybrids have been useful, as they have thrown light on the homologies of the genomes comprising the garden strawberry. Dr. Ellis also suggested that the wild species *Duchesnea indica* might be a *Fragaria–Potentilla* amphiploid. In the discussion on this paper, the bearing of Dr. Ellis's results on the taxonomy of *Potentilla* and its allied genera was referred to, as well as the cytological phenomenon of double non-reduction, observed in both *Fragaria* and *Solanum*.

The final paper, on "The Experimental Taxonomy of *Anthoxanthum* L.", was given in two parts. Dr. M. Borrill, of the Welsh Plant Breeding Station, Aberystwyth, spoke first, on the genetic aspects. In Europe and the Mediterranean, three main groups can be recognized: the arctic-alpine perennial diploid *A. alpinum*, the Mediterranean annual diploids *A. puelii* and *A. aristatum*, and the widely distributed tetraploid *A. odoratum*. Although the latter resembles *A. alpinum* very closely, it also possesses certain features, such as leaf pubescence, which occur in the Mediterranean diploids. *A. odoratum* hybridizes readily with the Mediterranean diploids, *A. alpinum* only with difficulty. However, a sterile diploid hybrid between *A. puelii* and *A. alpinum* was obtained, and from this a tetraploid plant was made by colchicine treatment. This plant is a vigorous perennial, is reasonably like *A. odoratum*, and is fairly fertile. It is also moderately self-fertile and can be inbred, unlike the very self-incompatible natural tetraploid. It seems reasonable to suppose that *A. odoratum* arose from a cross similar to that made artificially, though not necessarily from exactly the same parents.

Dr. K. Jones, of the Royal Botanic Gardens, Kew, then spoke about the cytological aspects of the problem. Natural populations of *A. odoratum* have invariably been found to be composed entirely of interchange heterozygotes. Some bivalents are always formed, but quadrivalents are common, and up to 10 chromosomes may be associated in a ring. These facts can be related to the probable mode of origin of the species. The artificial F_1 hybrid *A. alpinum* × *A. puelii* (described by Dr. Borrill) is a complex interchange heterozygote in which pairing varies from 5 bivalents to 1 bivalent and a ring of eight. The artificial amphidiploids derived from this hybrid are thus polyploid interchange heterozygotes, and, in the plants which have been studied, disjunction is not always regular. As a result of selection, the fully fertile natural tetraploid has developed in which there is regular disjunction and self-incompatibility. *A. odoratum* has thus become a stable and permanent interchange heterozygote.

A general discussion on all the papers was opened by Prof. Irene Manton, of the University of Leeds. After referring to a number of specific points, she raised the general question of the time scale of evolution, pointing out that in many of the groups discussed some fairly precise statements had been made which, if followed up, could give more exact information about the speed at which evolutionary adjustments happened than had hitherto been available. Thus it seemed certain that the physiological adjustments to soil described by Dr. Bradshaw must in some cases have occurred rapidly, since one example involved a disused quarry the age of which could be precisely determined. Evolution in *Œnothera*, described by Dr. Raven, seemed to be related to recent changes in the climate of western North America. In bananas, where parthenocarpy was a significant character, artificial selection by man must have been involved in the original Malayan habitat which could perhaps be roughly assessed in years; a significant part of the evolution of the cultivated potato as we know it to-day must have taken place in historical time. Recent advances in the experimental approach to evolution would now justify closer attention to the question of timing than would have been possible a few years ago, and it was strongly recommended that this attention should be given. In the discussion several speakers endorsed the view that certain sorts of evolutionary adjustment can occur surprisingly rapidly. Prof. G. L. Stebbins pointed out that the first stages in the evolution of the potato had not been quite so rapid as Prof. Manton had suggested, as the crop had a very long history in South America. He agreed with Prof. Manton as to the difficulty and complexity of the problem. The rate at which chromosome changes occurred often seemed to show little correlation with rate of change in the gene complexes which controlled morphological and physiological characters, and the causes of both kinds of change were still obscure. More accurate and detailed knowledge of the history of Tertiary floras might eventually provide a basis for firm conclusions.

D. H. Valentine

THE INDIAN INSTITUTE OF SCIENCE

THE Indian Institute of Science owes its existence to the vision of the late Mr. Jamsetti Nusserwanji Tata. In 1889, Mr. Tata, realizing the vital part that science could play in the advancement of human welfare, conceived the idea of founding a research institute which would have as its object the industrial welfare of India. Unfortunately, the founder did not live to see the fruition of his idea and it was left to his two sons, the late Sir Dorab Tata and the late Sir Ratan Tata, to fulfil their father's wishes, with the active support of the late Lord Curzon, then Governor General of India, and Sir K. Seshadri Iyer, who was at that time the Dewan of Mysore. The history of the Institute is presented in the February issue of *Science and Culture**; a short account of the Institute on the occasion of the jubilee also appeared in *Nature*, **183**, 644 (1959).

Mr. Tata offered property then worth two hundred thousand pounds (twenty-seven lacs of rupees) as an endowment for launching the Institute. In addition, the Government of Mysore offered 372 acres of land at the north end of Bangalore as a gift so that the Institute would be situated in one of the most favourable locations in India.

The Indian Institute of Science came into formal existence on May 27, 1909, as a postgraduate institution for the promotion of advanced studies and original research. The first batch of students was admitted in July 1911 to the Departments of General and Applied Chemistry and Electrical Technology. The Department of Organic Chemistry was added soon after. The Department of Biochemistry was opened in 1921, and the Department of Physics in 1933, when Sir C. V. Raman took charge as the first Indian director of the Institute.

From such modest beginnings it has progressed in a number of directions, and is to-day considered to be the leading centre of research and training in engineering and science in India.

The Institute functions as an autonomous body in accordance with a scheme formulated by the Government of India, under the Charitable Endowments Act. The Quinquennial Reviewing Committee (1955) recommended that, in place of the diplomas which it had so far been conferring, the Institute should confer degrees. The Institute is now deemed a university under the University Grants Commission Act of 1956.

During the Second World War the Institute took up for investigation a large number of schemes of research sponsored by the Council of Scientific and Industrial Research, the Council of Agricultural Research, the Indian Medical Research Council, and the Governments of Madras and Mysore. During that period, the Institute planned and established the Department of Aeronautical Engineering. At the close of the Second World War, a further four-year expansion programme was launched with grants from the central Government. Under the programme, the Departments of Metallurgy (1945) and Chemical Technology and Chemical Engineering (1951) were established and laboratories to carry out work on fermentation technology and pharmacology were set up.

For the training of power engineers, a Power Engineering Department was established in 1947, with separate laboratories for electrical, mechanical, civil and hydraulic engineering. A section on Economics and Industrial Psychology, including industrial relations, and affording facilities for research in these subjects, was also started in the same year.

In 1955, under a scheme for the development of facilities for technical education, additional postgraduate courses in automobile engineering (1956), foundry engineering (1956), soil mechanics and foundation engineering (1957), electronic engineering (1956), ultra-short and microwave engineering (1956), line communication engineering, and acoustical engineering were provided. Further facilities for research in technical gas reactions, physical metallurgy, hydraulic machines, internal combustion engineering, electrical measurements and measuring instruments, transmission, distribution and net-work practices have been added.

Recently a Department of Applied Mathematics and a section of Industrial Engineering Administration have been established.

The Library of the Institute, with about 63,000 volumes of current scientific and technical journals and books, occupies a high place among scientific libraries in India. The Institute celebrated its golden jubilee, commencing February 2, 1959, to mark the completion of fifty years of notable service to the cause of science and engineering in India.

* *Science and Culture*, **27**, No. 2 (February 1961).

THE INSTITUTE OF SEAWEED RESEARCH

THE annual report of the Institute of Seaweed Research, Inveresk, Midlothian, Scotland, outlines the expansion in the seaweed industry both in Britain and overseas*. This is due partly to an increase in the use of the seaweeds themselves and partly to the greatly increased use of seaweed extracts.

Seaweed meal factories at Gairloch, Lochmaddy, Kirkwall and Sanday all increased their production during 1960, and the products have found a ready market especially to compounders of animal feeding stuffs.

A retail market for seaweed manure has been developed by eight firms, and a new company has produced a soil conditioner made from seaweed, a liquid seaweed extract and a compost accelerator with a seaweed base. Liquid extracts are being used increasingly in agricultural practice.

Alginates continue to be of primary importance, and the Scottish market is holding its own against overseas competition, particularly from France and

* Institute of Seaweed Research, Inveresk. Annual Report for 1960. Pp. 23. (Inveresk, Midlothian: Institute of Seaweed Research, 1961.)

Nova Scotia. America, Iceland and Norway are all producing alginates commercially and there are new ventures in Holland, Australia and South Africa. Increased attention is being paid to the technology of seaweed products, and their use increases, especially in the food, textile-printing and paper-making trades.

The commercial use of mannitol is extending and it may be that its extraction from brown algae will become necessary, since its availability as a by-product in the manufacture of sorbitol does not meet the demand.

The Institute has continued to support fundamental research in a number of universities, and a summary is given of work on algal chemistry carried out in the University of Edinburgh under Dr. E. Percival and Dr. D. J. Manners, and on microbiology under the direction of Prof. G. E. Fogg at University College, London.

The report concludes with lists of publications during 1960, some of which are linked with the Institute while others concern relevant work of scientific importance or commercial development elsewhere.

PUBLIC HEALTH ENGINEERING

POSTGRADUATE courses in public health engineering were first given as a joint venture between the Imperial College of Science and Technology and the London School of Hygiene and Tropical Medicine during 1950. They were inspired by the International Health Division of the Rockefeller Foundation, which, besides giving generous financial aid during the first three years, also awarded many bursaries to enable students to attend the courses.

The courses have now become well established and, during the past eleven years, have been followed by 130 full-time and numerous part-time students from many parts of the world. From the start the aim of the courses has been to give a broad education in public health engineering, and emphasis has been placed on the importance of the public health aspects of the engineer's work.

The engineering studies have been supported by specially arranged courses in basic sciences, especially biology and chemistry, which are essential to the public health engineer but not normally taken by engineers, if at all, beyond the level achieved at school or first year at university. This broad treatment has made it possible to satisfy to a considerable degree the requirements of students from many different countries and of varying interests and experience.

It is now felt that some provision for alternative courses would be a great advantage, and it is proposed to provide two types of course from October 1961 *. The first is similar to the course which has been given since 1950. It is intended for engineers who will be employed mainly on the design or control of public health engineering works in Government or local authority departments, public works departments, water or sewerage undertakings or consulting engineers' offices. The second will be a new, broader type of course intended for persons with education and experience in engineering who are concerned with the general application of public health engineering measures rather than with detailed design. Such students will usually find employment in newly developing countries where many of the works with which they deal may be comparatively simple from the engineering point of view. These students require a complete knowledge of public health principles and practice, since their work is closely integrated with the public health services and they may have to initiate new methods of environmental control to meet a variety of health problems.

* Imperial College of Science and Technology; and London School of Hygiene and Tropical Medicine (University of London). *Postgraduate Courses in Public Health Engineering*. Pp. 15. (London: Imperial College of Science and Technology; and London School of Hygiene and Tropical Medicine, 1961.)

CHEMOTHERAPY OF MALARIA

IN a recent issue of the *W.H.O. Chronicle* *, Dr. L. J. Bruce-Chwatt, head of the Research and Intelligence Section of the World Health Organization's Division of Malaria Eradication, has outlined changes being made in the drugs used in the campaign to eradicate malaria. Dr. Bruce-Chwatt suggests that research on the biochemistry of anti-malarial drugs is badly needed and directs attention to the renewed interest in drug combinations and associations.

The rationale of the present use of drugs in malaria eradication programmes carried out by the World Health Organization is as follows:

(1) Schizontocidal drugs (chloroquine or amodiaquine) are used occasionally in the early stage of the attack phase, more generally in the late stage of the attack phase, and always in the consolidation phase for the 'presumptive treatment' given to all suspected cases of malaria for relief of clinical symptoms. The administration of a single dose of the drug to all detected fever cases is one of the characteristics of the surveillance activity that starts towards the latter part of an attack phase of malaria eradication, covers the whole of the consolidation phase, and extends over at least part of the maintenance phase.

(2) A sporontocidal drug (generally pyrimethamine) is often associated with the schizontocidal drug in the 'presumptive treatment' of the attack and consolidation phases with the purpose of making the suspected case of malaria non-infective to *Anopheles* vectors.

(3) Mass administration of schizontocidal drugs, alone or in association with such sporontocidal drugs as pyrimethamine or primaquine, has also been adopted during the attack phase together with residual spraying when the conditions are such that anti-anopheline measures are unlikely to have a rapid or complete effect. This use of drugs is still tentative; they have been given either as a single dose at long intervals at the time of residual spraying or as a repeated (weekly or monthly) dose for some definite period.

* *W.H.O. Chronicle*, **15**, No. 4 (April 1961).

The distribution of medicated salt is actually a variant of mass drug administration, applicable in conditions when residual spraying is not, for various reasons, feasible. Chloroquine or pyrimethamine has been used for admixture with salt, but the latter drug is no longer advocated for this purpose.

(4) Radical treatment of relapsing malaria means generally the use of 8-aminoquinolines for infections due to *Plasmodium vivax* and *P. malariae*, since that due to *P. falciparum* is cured easily by a standard three-day treatment with chloroquine or amodiaquine. The proper administration of daily primaquine or quinocide over a fourteen-day period is often difficult without a wide network of medical services, and in such cases large single doses or smaller repeated doses of a sporontocidal drug (pyrimethamine) have been tentatively given.

The following aspects of chemotherapy are among those of immediate interest for malaria eradication. There is a great difference between the approach of the clinician interested in treatment of a case of malaria and that of the malariologist whose aim is the eradication of this infection from a large community. From the point of view of the clinician no new anti-malarials are really necessary; he has quinine or, preferably, one or other of the 4-aminoquinolines for treatment of severe infections; if he wants to prevent relapses one of the modern 8-aminoquinolines—safe when given with some elementary precautions and almost 100 per cent reliable—is available; for protection from infection the clinician has the choice of proguanil, pyrimethamine, and (in the second place) chloroquine or amodiaquine; any of these drugs will serve his purpose when given at proper and regular intervals.

For the malariologist, each of these drugs has one flaw: it must be given in regular, repeated doses to achieve its effect on the transmission of malaria. In this respect they are often a failure when used on a large scale in countries without extensive and well-organized medical and public health systems. In reassessing the problems of chemotherapy in malaria eradication two questions may be asked: How can the best use be made of the anti-malarials now available?, and, What new drugs are needed, if any?.

Improvements in operational conditions, better co-operation from an enlightened community, or the introduction of some relatively simple technical innovations may remove a number of obstacles to a wider use of drugs in malaria eradication, but are not always feasible in under-developed areas with inadequately organized public health services.

What new drugs are needed? The answer is that at least two types of anti-malarials must be developed: (1) A potent and safe schizontocidal drug which will maintain its effect for 3–6 months after a single dose. It would be advantageous if this drug had a rapid and prolonged sporontocidal action. (2) A good and safe anti-relapse drug capable of effecting a radical cure of *vivax* and *malariae* infections when given in a single dose or, at the most, in a three-day course of treatment. Over the past five years the development of new anti-malarial drugs has not been so fast or so successful as expected.

There are two reasons for the apparent lack of drive in research on new anti-malarials: one is the empirical approach to the investigation of new compounds and the other is the growing difficulty of gauging their value in human malaria; little is known about the metabolism of the infected cell.

PHYSICAL ANTHROPOLOGY OF AUSTRALIAN ABORIGINES

SINCE 1951 the Department of Anatomy of the University of Adelaide has sent out seven field expeditions to study the physical anthropology of the aborigines in different parts of Australia, and the first complete trans-continental survey—from Fowler's Bay (Yalata) on the south coast to the Liverpool River in northern Arnhem Land has now been compiled.

The survey covered most metrical and non-metrical characters. Much of the information collected has yet to be analysed statistically, but some features are emerging to warrant preliminary consideration. These have been reviewed by Prof. A. A. Abbie of the Department of Anatomy, University of Adelaide, South Australia*.

Divergent opinions on whether the aborigines are homogeneous or heterogeneous lend interest to a comparison of some physical measurements of three aboriginal groups, separated from each other by some 800 miles of territory and all living in different environments.

The groups are, respectively, (*a*) a composite southern group assembled near Yalata on the south coast; (*b*) two neighbouring tribes of central Australia —the Pintubi and the Wailbrai: and (*c*) a tribe near the mouth of the Liverpool River in northern Arnhem Land, the Burera. In the present paper only adult males are considered as being most representative of their groups. The numbers examined—Yalata, 33; Pintubi, 38; Wailbrai, 30; Burera, 26—are about the maximum obtainable in any tribe in a reasonable time. All except the Yalata group had come under European influence only shortly before the time of examination.

The figures indicate that, right across the continent, through a wide diversity of environments, the aborigines exhibit an extraordinary degree of physical homogeneity.

Up to the age of about 5 years, the physical proportions of aboriginal children are about the same as those of comparable Europeans. Between 5 and 6 years, however, aboriginal children suddenly show a marked extension of the inferior extremities that reduces the relative sitting height to about 50 per cent —close to the proportions of European children of around 12 years. Thereafter, until the cessation of growth, the aborigines preserve their six years' advantage and finish with a relative sitting height close to 46 per cent.

So far this has been worked out fully only for the central Australian males, but a preliminary survey of the data indicates that it holds for both sexes and for most northern and most southern groups as well.

New-born aborigines are pinkish-yellow with some darker colouring around the nipples, navel, genitalia and buttocks. The rate of darkening of the skin seems to depend on the degree of exposure to the

* *Australian Journal of Science*, **23**, No. 7 (January 1961).

Sun and full pigmentation may be acquired in one week or not for two or three weeks. The oral mucosa may be patchily pigmented in infancy, but usually not until eruption of the first permanent molars. The darker colouring starts around the anterior gum margins and spreads to the general mucosa and the palate with advancing maturity. There is a tendency towards fading in old age. In tribes that practise circumcision, at the time of operation (about puberty) the glans penis is pink or only slightly pigmented; in adult circumcized males the glans is as dark as the surrounding skin.

In most aborigines the skin is reddish-brown or chocolate, but more intense exposure—as in the desert or far north—produces a much darker colour. Those who wear clothes regularly tend to lose some of their melanin and fade, sometimes to near the original pinkish-yellow in parts. Such people are liable to sunburn on unaccustomed exposure.

Head hair is usually dark brown to black, but blondness—ranging from quite flaxen to reddish-brown—is common in the children of central and south Australia. The fine hair of the body is also fair, but all other aspects of pigmentation—skin, eyes, eyebrows and lashes—are as in all other aborigines. In boys the scalp hair begins to darken at 8–10 years and becomes black or dark brown, like the hair of axillæ, pubes and beard, before the age of twenty. Girls start to darken later—in adolescence—and even when adult may still only be mid-brown on the scalp although axillary hair and pubic hair is dark brown or black. In the far north light scalp hair is less common, but it occurs, and usually with a redder tinge. Light body hair is quite common there in women and children, however. This blondness probably has a genetic basis; it is certainly not due to kwashiorkor, or other nutritional disturbance.

Aborigines living under native conditions have relatively low blood pressures. In the western desert men at 40 years averaged 75–109 mm. mercury and women slightly less. At Government settlements, where living is easier and some European food is available, male pressures were 79–119, female 76–110. In a more or less urban environment male pressures averaged 89–131 (very similar to European males under similar conditions), female 75–115. In northern Arnhem Land pressures expressed on the same basis were: males 84–116, female 82–113.

All aborigines so far examined have high serum protein-levels, especially in the γ-globulin range. Serum cholesterol-levels are comparatively low in desert-living aborigines and there does not appear to be any rise with age as occurs in Europeans. Aboriginal cholesterol-levels rise with increasing Europeanization (roughly paralleling the rise in blood pressures), but not, so far, to European-levels. Serum phospholipid and mucoprotein levels also rise under the same conditions.

WEATHER FORECASTING BY NUMERICAL METHODS

THE advent of the electronic computer has made it possible to attempt weather prediction by numerical processes. The idea is to observe an initial state of the atmosphere, apply Newton's laws and the laws of conservation of energy and mass, together with the appropriate gas laws, and hence predict the condition of the atmosphere at some time in the future, rather as the motions of heavenly bodies are predicted in astronomy. The earliest attempt was made by L. F. Richardson between the World Wars and is described in his classic book. Richardson visualized an army of computers, just able to keep up with the weather. He did not visualize computing machines, and their widespread use has changed the position, for an electronic computer can get ahead of the weather quite easily.

Active work on this subject is now proceeding in the United Kindom, Belgium, Holland, Norway, Sweden, Japan, and several centres in the United States. A recent publication from the Meteorological Office* describes some of the work being done in the forecasting research division. This paper, considered together with recent work in the United States deserves special attention because, for upper-wind forecasting, numerical methods now surpass conventional methods of forecasting. This does not mean that the conventional forecaster with his weather-maps will disappear, because, as yet, it is only the winds which are forecast numerically, not the equally important weather. A housewife may like to know that Monday will be windy because this will facilitate drying clothes, but she is more interested in whether or not it will rain. Numerical methods at present either do not attempt to predict this or they do so very badly.

It is obvious that the atmosphere is a very complicated affair, yet the primitive (partial differential) equations expressing the laws mentioned above look beguilingly simple. They do, however, include all the motions of the atmosphere, the steady trade winds on the surface, the great jet-streams in the upper air, depressions and anticyclones, tornadoes and showers, to mention only a few of the varied phenomena. Almost always the first thing, therefore, is to simplify the equations so that only events significant to the scale of weather concerned remain. The resulting simplified system of equations and the somewhat artificial 'atmosphere' it describes then become a 'model'.

In the United States experience is that the simplest and earliest model—the barotropic model—remains the best for forecasting large-scale phenomena. After pioneer work by J. Charney, the great labour of extensive trials has been borne by a joint numerical weather prediction group at Suitland, Maryland. The model regards the atmosphere as describable in every way by events at one level only, and the resulting simplified atmosphere is called the equivalent barotropic atmosphere. By extending the calculation to include almost the whole northern hemisphere, and by correcting artificially for the unexplained incorrect backward motion predicted for the phenomena of the largest scale, a useful extra skill above the conventional forecaster is obtained and, for long-range air navigation, winds forecast in this way are now used in the United States.

* Air Ministry: Meteorological Office. Scientific Paper No. 5: *An Experiment in Numerical Forecasting*. By E. Knighting, G. A. Corby, F. H. Bushby and C. E. Wallington. (M.O. 682.) Pp. iii + 67. (London: H.M. Stationery Office, 1961.) 5s. net.

In a barotropic atmosphere, by its very nature, kinetic energy cannot be generated, and this is clearly unnatural since without the continuous generation of energy the atmosphere would slow down and soon be stopped by the drag of the air on the ground. This fundamental unreality would appear to be very unsatisfactory. However, it is now generally accepted that the large-scale motions of the general circulation, for which the barotropic model succeeds so well, do not have their own source of energy, but derive it from the more ordinary phenomena, such as the depressions of temperate latitudes. In most fluid-flow problems the small vortices obtain their energy from the general flow, and it is a remarkable property of the atmosphere that here the reverse occurs. It is therefore reasonable that phenomena which have no internal energy source can be described by a model which provides none, but this model would be expected to fail when kinetic energy was obviously being generated. This is found to be the case and most of the active groups working on the problem are experimenting with more complicated models which can provide the necessary source.

In the Meteorological Office the effort available is relatively small, and it has been mainly concentrated on the two-layer models which arose naturally out of Sutcliffe's early work. In the work of all groups, much of the success which has been claimed for the complicated models appeared to rest suspiciously on the isolated events which had been used to test them, the model being adapted until it succeeded, but presumably its success was isolated because these models have not appeared in service use. The Meteorological Office, in its Scientific Paper No. 5, has now published the results of a substantial test of a two-layer model, and some significant success is achieved. The forecasts appear to have a just significant superiority over conventional methods. The workers have been handicapped by the need to work over a limited area so that the influence of events outside the region of computation is not negligible, and it is to be hoped that they will be able to increase their scale of operations in the future.

It seems that the slow improvement in the accuracy of weather forecasting must be accepted. Conventional methods using weather charts, the dynamic methods discussed above and elaborate statistical methods all seem to achieve a success only a little better than persistence. They then progress either no more, or very slowly. It may be that the block is because the weather is in fact indeterminate and it will never be possible to do much better, but surely that is a gospel of despair.

A. W. Brewer

PRECIPITATION OF SUB-MICRON DUST IN STILL AIR BY CLOUD-SIZE WATER DROPLETS

By Dr. M. M. BHADANI and N. G. T. LUDLOW

Department of Mining and Minerals Engineering, The University, Edgbaston, Birmingham, 15

A SEARCH of available literature indicates doubt as to the possibility of precipitating sub-micron dust dispersions in air by means of water droplets falling under gravity. The results of a preliminary investigation of this problem by Bhadani[1] indicate that such precipitation occurs readily under conditions described in this article.

Some fields, in which further extensions of research into the behaviour of fine aerosols in general may have special significance, are discussed briefly.

That such fine dust is produced in certain industrial processes is discussed by Sichel[2], who records large percentages of dust of less than 0·1μ from mine-drilling operations. In certain foundry operations, too, high percentages of 0·05–0·10μ grains have been reported[3].

The potential significance of sub-micron particles in lung pathology has been established by Pollicard[4], Dautrebande *et al.*[5], and others, who have shown that such fine particles can penetrate into the lung alveoli.

A method of coagulation of fine dust and sodium chloride aerosols, both in Brownian motion, is described in refs. 6–8. When breathed into the lungs, the hygroscopic sodium chloride-dust agglomerations grow larger by absorption of moisture and are deposited in the larger air tracts before reaching the alveoli.

The finer particles present in atmospheric pollution comprise both man-made and naturally occurring substances. Cartwright and Skidmore[9], in surveys of airborne dusts in South Wales coal mines, concluded that atmospheric pollution entering the mines with the ventilating air current made it difficult to assess the sub-micron dust actually produced in the mining operations.

In meteorology great importance is attached to the function of fine particles present in the atmosphere in acting as condensation or freezing nuclei in the process of cloud and rain formation. Simpson[10] notes the presence in air of naturally occurring hygroscopic nuclei such as salt from sea spray and nitrous acid from atmospheric nitrogen, in addition to non-hygroscopic materials. Nolan and Doherty[11] have recorded the presence in Dublin air of condensation nuclei of 0·01–0·10μ size and with varying concentrations up to about 9×10^4 particles/c.c. of air and more. Bowen[12] has produced evidence showing a possible relationship between regularly occurring meteoric dust streams and peak rainfall periods in various parts of the world. Cwilong[13] has found nuclei concentrations of about 10^5 particles/c.c. of air coinciding with abnormal rainfall and meteoric dust showers. Ludlam[14] has estimated that cosmic dust may settle into the atmosphere at a sufficient rate to provide concentrations of Aitken nuclei near ground-level of 100 particles/c.c.

When bulk coal from the top seam of the Khost-Sharig colliery, Baluchistan, Pakistan, or silica dust (that is, dust produced by grinding) is dispersed in air in a confined space, the larger particles soon settle out by gravitational effect, leaving behind a fine residual dust suspended in the air medium. Residual dust, prepared in this way in a metal chamber (17 in. × 17 in. × 30 in.), has been found to consist of particles largely in Brownian motion.

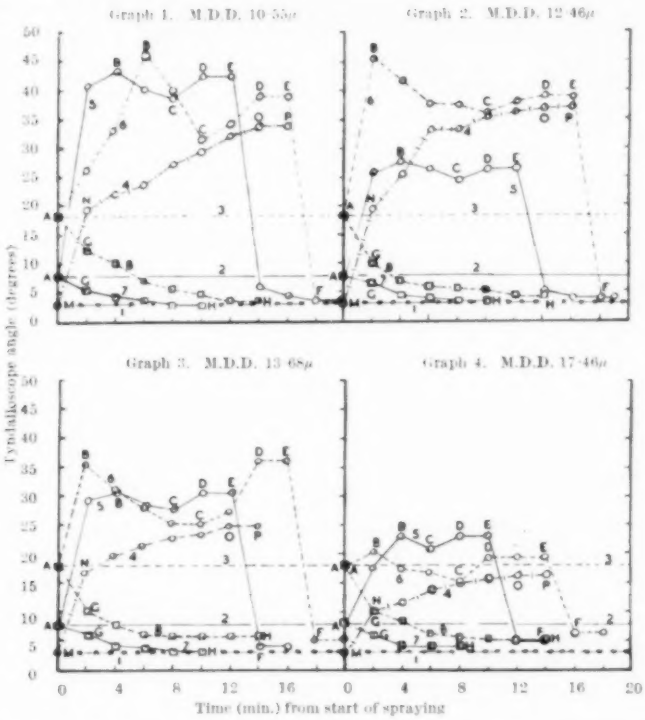

Graph 1. M.D.D. 10·55μ
Graph 2. M.D.D. 12·46μ
Graph 3. M.D.D. 13·68μ
Graph 4. M.D.D. 17·46μ
Tyndalloscope angle (degrees)
Time (min.) from start of spraying

Fig. 1. Water spray precipitation for residual coal and silica dusts, with related curves. Average mean diameter of dusts used, 0·14μ. (1) Instrumental zero reading of +3°. (2) Constant scatter angle for residual Pakistani coal dust dispersion in the absence of spray. (3) Constant scatter angle for residual silica dust dispersion in the absence of spray. (4) Curve for spray in the absence of dust. (5) Precipitation cycle for residual Pakistani coal dust with continuous water spray. (6) Precipitation cycle for residual silica dust with continuous water spray. (7) (AGH). Precipitation curve for residual Pakistani coal dust with intermittent spray. (8) (AGH). Precipitation curve for residual silica dust with intermittent spray. M.D.D. = mean droplet diameter

The average mean diameter of the particles was 0·14μ and the concentration 9×10^4 particles/c.c. of air. The concentration in the chamber was measured by means of the light-scatter angle of a Tyndalloscope. The Tyndalloscope readings of the residual dust suspensions before commencement of spraying were found to remain constant for several hours, the values being 7·8° and 18° for the coal and silica dusts respectively. This indicates a steadily maintained dust dispersion in which coagulation, diffusion or settling were not important factors during the period of the experiments.

When the steady state of the residual dust suspension in the chamber was indicated by the constant Tyndalloscope reading, water droplets were introduced into the upper portion of the chamber by means of a May[18] type spinning top driven by compressed air. The Tyndalloscope angle was read at 2-min. intervals during the precipitation cycles.

Four sets of typical precipitation cycles and related curves for residual coal and silica dusts are shown in Fig. 1, graphs 1–4, using water spray with mean droplet diameters of 10·55, 12·46, 13·68 and 17·46μ in separate experiments. The same rate of water-flow (2·4 c.c./min.) was used in each case.

Particular consideration is given here to the continuous spray precipitation curves 5 and 6 for coal and silica dust, respectively.

Entering these curves at *A*, on the line of steady scatter angle of the coal or silica dispersed in the chamber, the sprayer is started. The Tyndalloscope scatter angle increases rapidly from *A* to *B* as the combined effect of mist in the presence of dust is registered. From *B* the angle decreases sharply to *C* and then soon again increases to *D*, after which it remains constant, indicating equilibrium conditions. At *E* the spray is stopped and the portion of the curve *E* to *F* is clearly related to the diminution of concentration, as the droplets plus remaining precipitable dust fall to the floor of the chamber.

An interesting feature of these continuous spray precipitation curves is the fall in scatter angle *B*–*C* followed by the rise *C*–*D*. It is thought that this may be in part due to a temporary shower of dust-laden droplets. Evidence of substantial dust precipitation by droplet assimilation is seen in Fig. 2. This shows an electron microscope photograph of a droplet which has fallen directly on to a 'Formvar'-covered specimen grid, placed in the floor of the chamber.

Comparing all the precipitation curves for the coal and silica dusts, it is noticeable that the smaller droplets are somewhat more effective in eliminating the dust from suspension than the larger droplets. Also the coal dust is more readily precipitated than the silica dust.

The reasons for the diverse precipitation characteristics of coal and silica are not fully understood. The contrasting physical properties of coal and silica in the presence of water vapour may be important in this connexion. It is well known that coal absorbs water vapour[16–19]. To illustrate this point in the present work, equal weights of the bulk silica and coal dusts were placed in separate vessels on the floor of the experimental chamber, sheltered from falling droplets, but with open

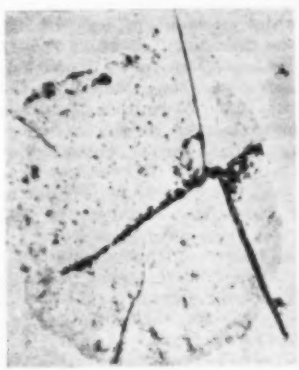


Fig. 2. Electron microscope photograph of dust-laden water droplet (× 1020)

access to the atmosphere of the chamber. It was found that the increase in weight of the coal dust attributable to water vapour adsorption was more than 100 per cent, whereas that of the silica dust was negligible.

Our thanks are due to Prof. Stacey G. Ward, head of the Department of Mining and Minerals Engineering, for help and advice in the research and in the preparation of this article.

[1] Bhadani, M. M., "An Investigation of Fine Dust Precipitation by Water Droplets", Ph.D. thesis, University of Birmingham (1958).
[2] Sichel, H. S., *J. S.A. Inst. Min. Met.*, **58**, 171 (1957–58).
[3] Guthman, D., Abs. from *Radex Rundschau*, 6 (1958); *Iron and Coal Trades Rev.*, **178**, 831 (1959).
[4] Pollicard, A., Collet, A., and Ralyte, L., *Presse Medicale*, **60**, 1419 (1952).
[5] Dautrebande, L., Beckmann, H., and Walkenhorst, W., *A.M.A. Arch. Indust. Health*, **19**, 383 (1959).
[6] Dautrebande, L., *L'Aerosalogie* (J. B. Baillière, Paris, 1951).
[7] Chakravortty, J. C., *Coll. Guard.*, **190**, 605 (1955).
[8] Walkenhorst, W., and Zebel, G., *Beitr. Silikoseforsch.*, 44 (Silikose-forschungsinstitut, Bochum, 1956).
[9] Cartwright, J., and Skidmore, J. W., *S.M.R.E., Res. Rep.*, No. 133 (1957).
[10] Simpson, G. C., *Quart. J. Roy. Met. Soc.*, **67**, 163 (1941).
[11] Nolan, P. J., and Doherty, D. J., *Proc. Roy. Irish Acad.*, **53**, 10 (1950–51).
[12] Bowen, E. G., *Australian J. Phys.*, **6**, 494 (1953).
[13] Cwilong, B. M., *Nature*, **176**, 129 (1955).
[14] Ludlam, F. H., *Nature*, **177**, 321 (1956).
[15] May, K. R., *J. Appl. Phys.*, **20**, 939 (1949).
[16] Graham, J. I., *Trans. Inst. Min. Eng.*, **62**, 302 (1921).
[17] Briggs, H., and Sinha, R. P., *Trans. Inst. Min. Eng.*, **87**, 203 (1933).
[18] Ludlow, N. G. T., *Coll. Guard.*, **179**, 267 (1949).
[19] Sevenster, P. G., *Fuel.*, **38**, 403 (1959).

VISCOSITY OF DUSTY GASES

By Dr. WAYNE T. SPROULL
Western Precipitation Division, Joy Manufacturing Co., Los Angeles

IF dust is added to gas flowing turbulently through a pipe or other system, the difference, H, in pressure required to maintain the flow at its original (clean) rate, V, decreases immediately. For air, a dust concentration of $\frac{1}{4}$ kgm./m.^{3} decreases H about 13 per cent. Or, if H is held constant, the addition of the dust increases the flow-rate about 6$\frac{1}{2}$ per cent, the flow being proportional to the square root of H. These quantitative results were determined by Dr. Leo W. Briggs in our laboratory in 1945, but never published. The qualitative observation that the gas-handling capacity of a cyclonic dust collector increases considerably with the dust concentration was familiar here about 1935 or earlier.

Curiosity about this effect led to the present investigation. Obviously, addition of 0·25 kgm. of dust to a cubic metre of clean air, which has a mass of about 1·2 kgm., will increase its density to about 1·45 kgm./m.^{3}. Such a 21 per cent increase in the density could be achieved by, for example, cooling the air sufficiently, and both theory and experiment agree that such an increase in density due to temperature reduction will *increase* the value of H required to keep V constant by 21 per cent. Yet Briggs found that H *decreases* about 13 per cent when this same 21 per cent density increase is achieved by suspending dust in the air (or other gas).

The probable explanation seemed to be that addition of the dust must decrease the viscosity of the gas in order to account for its decreased resistance to flow through pipes, etc. Moreover, the decrease in the viscosity must be quite a large one, because empirical equations such as the so-called 'Fanning equation' show that, for a constant flow-rate V, H varies as the 0·25 power of the viscosity. Thus, the observed 13 per cent reduction in H for a dust concentration of $\frac{1}{4}$ kgm./m.^{3} would imply a 43 per cent reduction in the viscosity. This seemed difficult to believe; yet no other explanation could be found.

In 1958, I conducted some preliminary tests with a viscosimeter and found a decrease of about 40 per cent in the viscosity of air, from about 180 to about 110 μpoise, when limestone dust was suspended in it at a concentration of about $\frac{1}{4}$ kgm./m.^{3}. These results were published only in abstract form[1]. The viscosimeter used in 1958 was constructed with a horizontal disk, suspended by a torsion wire, 5 mm. above a second horizontal disk driven by a motor at 78 rev. per min. Dust settled rapidly on the disks at the heavy concentration required, and this left some room for doubt about the reliability of the results.

Therefore the experiments were repeated in 1960, using a viscosimeter having a vertical sensing cylinder suspended coaxially within a rotating cylinder, as shown in Fig. 1. It was not possible to work under steady-state conditions in either the 1958 or 1960 experiments. If dust-laden air from the dust-dispersing device had been blown steadily through the viscosimeter cabinet with a dust concentration of $\frac{1}{4}$ kgm./m.^{3} over a period of, say, 20 min., the dust settling within the cabinet would have been so great as to fill it about half full and completely spoil the operation of the viscosimeter. Even in 1 min., the dust settling on the floor of the cabinet amounted to about 1 in. at these heavy concentrations. Thus each test had to be conducted rapidly and a result obtained within 1 min. The procedure was to blow clean air through the viscosimeter cabinet at the maximum rate attainable without undue disturbance of the inner sensing cylinder. After noting the 'zero' deflexion, the outer cylinder was started rotating; the change in the deflexion was taken as a measure of the viscosity of the clean air (about 180 μpoise). Next, dust was fed into the disperser at a rate sufficient to yield the desired concentration, for about 1 min. During this time, the deflexion of the inner cylinder decreases due to the reduced viscosity, and the reduced value must be determined.

The annulus between the two cylinders was 5 mm. wide in some tests and 7$\frac{1}{2}$ in others. More than one value was also used for the speed of rotation, 25 and 50 rev. per min.; for the dust concentration, 60 and 240 gm./m.^{3} approximately; and two types of dust were used. One was limestone dust consisting 40 per cent by weight of particles smaller than 10μ diameter; the other was talc dust 99 per cent by weight smaller than 10μ. Although the density of the individual particles was nearly the same for these two dusts (2·5 gm./c.c. for talc and 2·6 gm./c.c. for limestone), the talc dust had a bulk density of only about 0·3 gm./c.c., as contrasted with about 1·3 gm./c.c. for the limestone dust. The results follow:

Test series	Dust	Approximate concentration (gm./m.³)	Cylinder speed (r.p.m.)	Annulus width (mm.)	Observed viscosity reduction (per cent)
1	Limestone	240	50	7½	40
2	Talc	240	50	7½	38
3	Talc	60	50	7½	10
4	Talc	60	50	5	10
5	Talc	240	50	5	35
6	Limestone	240	50	5	24*
7	Limestone	240	25	5	24*

Each of the seven values in the last column of the above table is an average of several tests. The last two, marked with asterisks, are to be discounted on the grounds that with the narrow 5-mm. annulus, the comparatively coarse limestone dust could not be forced through the apparatus fast enough to prevent excessive settling, without disturbing the sensing cylinder unacceptably. Consequently, settling reduced the dust concentration in series 6 and 7 to a value considerably less than the ¼ kgm./m.³ at which it entered the viscosimeter cabinet. These two series did indicate, however, that the result is insensitive to cylinder speed.

The tests of two such different dusts as limestone and talc, with nearly identical results, indicate that the concentration of the dust (mass per unit volume of the gas) is the main factor in the effect, and that the particle size and bulk density of the dust are relatively unimportant. The present results confirm the 1958 results and indicate that dusty gas flows through pipes with a smaller resistance than clean gas, because the dust reduces its viscosity. This work has also been published in abstract form[2] only.

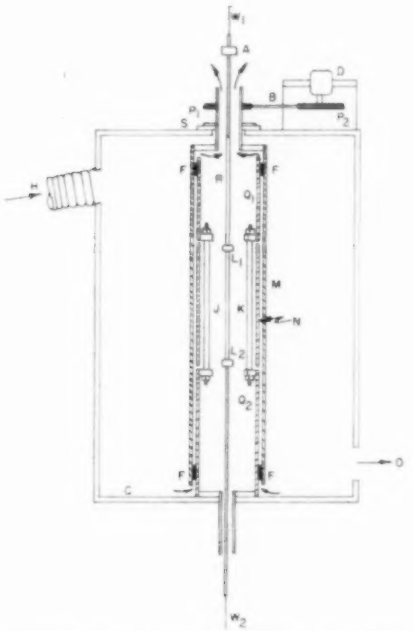


Fig. 1. Vertical section of the viscosimeter and enclosing cabinet. Dust-laden air is blown in at *H* and out at *O*. Some of it also escapes via the route shown by the arrows near *F* and *A*, which carries it through the annulus between the outer driven cylinder *M* and the inner sensing cylinder *N*. *N* is attached by lugs *L* to rod *R*, which is supported and aligned by taut wires W_1 and W_2. The torque transmitted to *N* by the viscous action of the gas in the annulus twists wires *W* through a few degrees, the angle being measured accurately by means of a light beam reflected from mirror *A*. The stationary cylinders Q_1 and Q_2 eliminate end-effects at the top and bottom of cylinder *N*

What is the physical explanation for such a large reduction in the viscosity of a gas when dust is suspended in it? Elementary kinetic gas theory states that the viscosity, η, is given by:

$$\eta = \tfrac{1}{3}\rho\bar{c}\lambda \qquad (1)$$

where ρ is the gas density, $\bar{c}$ is the average molecular velocity, and λ is the mean free path. At constant temperature, as in the present experiments, $\bar{c}$ remains constant. The addition of dust can only increase the density, ρ; hence the observed decrease in viscosity is presumably due to a decrease in the mean free path, λ, which in simple kinetic theory is given by:

$$\lambda = \frac{1}{\sqrt{2}\pi N\sigma^2} \qquad (2)$$

where N is the (Loschmidt) number of molecules per cubic centimetre and σ is the diameter of the molecules.

If the dust cloud is regarded as a second 'gas' mixed with the true gas in which it is suspended, the expression for λ_g, the mean free path of the gas molecules in the dust-laden gas, becomes[3]:

$$\lambda_g = \frac{1}{\sqrt{2}\pi(N_g\sigma_g^2 + N_d\sigma_d^2\sqrt{1 + m_g/m_d})} \qquad (3)$$

where N_d is the number of dust particles per c.c., σ_d is the diameter and m_d the mass of a dust particle (assumed the same for all). The g subscripts designate similar symbols for the gas molecules. m_g is negligible compared to m_d, so the final radical reduces to 1. Also, $N_d\sigma_d^2$ is small compared to $N_g\sigma_g^2$, and unless this circumstance can be changed, equation (3) reduces to equation (2). The only way that $N_d\sigma_d^2$ could be made comparable in magnitude to $N_g\sigma_g^2$ for the dust concentrations used in the present experiments is to assume that σ_d is an 'effective' diameter, which might be appreciably larger than the actual diameter of the dust particles. Since σ_d is squared, an effective diameter equal to, say, 50 times the actual diameter, increases $N_d\sigma_d^2$ by a factor of 2,500, and this is sufficient to make its value comparable to $N_g\sigma_g^2$, thus causing equation (3) to indicate a reduction in λ_g of about 50 per cent, which, from (1), would account for a reduction in the viscosity of about 50 per cent, as observed.

Taking the experimental data and reversing the calculation above, one concludes that if the dust particles were all 1μ in diameter, their 'effective' diameter, σ_d must be about 150μ. This suggests that the explanation of the observed effect may be that each dust particle is surrounded by a 'boundary layer' of gas adhering to it. This is not a new concept; indeed, the derivation of Stokes law for the settling of dust particles in a gas[4] presupposes the existence of such a boundary layer. An expression for the approximate magnitude of its thickness is[5]:

$$\delta = \sqrt{\frac{\eta\sigma}{\rho v}} \qquad (4)$$

where v, in the case of a suspended dust particle, would be the difference in the gas velocities on opposite sides of the particle. From the known velocity gradient in the viscosimeter annulus, one may calculate v for the case of a 1μ diameter particle, and thus evaluate δ from equation (4). The result is about

100–500μ, thus agreeing reasonably with the value calculated for σ_4.

Thus, one is left with a picture of the suspended dust particles each surrounded by a gaseous boundary layer thick enough to make its 'effective' diameter some 50 or 100 times as great as its actual diameter. This increases the 'cross-section' of the particles sufficiently to cause the gas molecules to collide with these boundary layers just about as often as they collide with unattached molecules (that is, molecules not making up a boundary layer for some dust particle).

A modification of this picture may also be worth considering. The velocity gradient in the viscosimeter annulus causes a force in one direction on one side of any dust particle suspended therein, and a force in the opposite direction on the opposite side of that same particle. This couple should cause the particle and its boundary layer to rotate somewhat like the balls between the races of a ball bearing. For a typical velocity gradient such as 50 cm./sec. per cm., the rate of rotation of the suspended particles should be roughly 8 or 10 rev. per sec. This 'ball bearing' concept may also help account for the observed reduction of viscosity.

The effect discussed in this article may have some significance in meteorological theories of rainstorms, etc., and may even be worth considering in cosmological theories of the evolution of stars and planets from dust-laden gases. It is also possible that this phenomenon might be applied to develop a practical instrument for measuring dust concentration in industrial smoke-stacks and flues.

[1] Sproull, W. T., *Bull. Amer. Phys. Soc.*, II, **3**, 411 (1958).
[2] Sproull, W. T., *Bull. Amer. Phys. Soc.*, II, **5**, 497 (1960).
[3] Jeans, J. H., *The Dynamical Theory of Gases*, fourth edit., 252 (Cambridge Univ. Press, 1925).
[4] Schlichting, H., *Boundary Layer Theory*, 85 (Pergamon Press, London, 1955).
[5] Ewald, P. P., Pöschl, T., and Prandtl, L., *Physics of Solids and Fluids*, second edit., 248 (Blackie and Son, Ltd., London, 1936).

BIOCHEMICAL CHANGES ACCOMPANYING IMPAIRED RESPIRATION IN STAPHYLOCOCCI

By Prof. G. F. GAUSE, G. V. KOCHETKOVA and G. B. VLADIMIROVA

Institute of Antibiotics, Academy of Medical Sciences, Moscow

In a recent discussion of the cancer problem[1], mutants of yeasts with impaired respiration have been compared with cancer cells which also have a respiratory deficiency. In this connexion, mutants of staphylococci with oxidation defects which can be observed in cultures of some strains are of great interest[2,3].

A new method has been developed for the isolation of staphylococci with respiration deficiency from parent cultures, which is based on the selective inhibitory action of some fluorinated pyrimidines (Table 1), recently prepared as a new class of tumour-inhibitory compounds. The growth of staphylococci with impaired respiration (mutant *ur*-3) is approximately sixty times more vulnerable to the inhibitory action of 5-fluorouracil than the growth of the initial parent culture (*S. aureus* 209). In both cultures the inhibitory action is reversed by uracil, but not by thymine. On the other hand, 5-fluoro-2-deoxyuridine inhibits growth of the parent culture of staphylococci much more effectively than 5-fluorouracil, and this inhibition is reversed by thymine but not by uracil.

It therefore appears that 5-fluorouracil and 5-fluoro-2-deoxyuridine are blocking different metabolic pathways in staphylococci. In accordance with present views, 5-fluoro-2-deoxyuridine blocks the formation of thymine which is required for the synthesis of deoxyribonucleic acid[4]. It is very significant that 5-fluoro-2-deoxyuridine does not inhibit the growth of mutants with impaired respiration either in liquid or solid media, even at the maximum concentration tested, namely, 1,000 μgm./ml. This points to the possible synthesis of deoxyribonucleic acid thymine by different pathways in mutant and parent strains. Another possible explanation for this phenomenon is that it may reflect the relative impermeability of the mutant cell to 5-fluoro-2-deoxyuridine, so that the drug does not reach the site of its action.

Table 1. Concentration of Some Fluorinated Pyrimidines required to Inhibit the Growth of Staphylococci in Liquid Broth

Compound	Micro-organism	μgm./ml.
5-fluorouracil	*Staph. aureus* 209	125
,, + thymine (100 μgm./ml.)	,,	125
,, + uracil (100 μgm./ml.)	,,	500
5-fluorouracil	Mutant *ur*-3	2
,, + thymine	,,	2
,, + uracil	,,	25
5-fluoro-2-deoxyuridine	*Staph. aureus* 209	25
,, + thymine	,,	100
,, + uracil	,,	25
5-fluoro-2-deoxyuridine	Mutant *ur*-3	> 1,000
,,	Mutant *ur*-2	> 1,000

The observations given above were used for the development of liquid nutrient medium, selectively inhibiting the growth of parent staphylococci and favourable for the multiplication of mutants with impaired respiration. For this purpose a nutrient broth containing peptone (0·5 per cent), glucose (1 per cent), sodium chloride (0·5 per cent), Hottinguer digest (30 ml./l.), corn steep liquor (0·2 per cent), and 5-fluoro-2-deoxyuridine (100 μgm./ml.) was distributed into test-tubes, and seeded with suspensions of the parent cultures of staphylococci (strains 209, *D*, *G*, and 121). The staphylococci were previously grown on meat-peptone agar for 24 hr. at 37° C., washed using physiological saline solution, diluted to a concentration of 2×10^8 cells/ml. and added to the selective medium in the amount 0·10–0·05 ml. per 1 ml. of broth. Parent staphylococci did not grow on this medium due to inhibitory action of 5-fluoro-2-deoxyuridine, but any mutants with impaired respiration which were present in the parent inoculum multiplied. If, after 5–7 days of incubation of such tubes at 37° C., their contents were plated on nutrient agar containing 5-fluoro-2-deoxyuridine (25 μgm./ml.), in some cases pure cultures of mutants were observed instead of the parent culture. These mutants were observed more frequently in the strains *D* and 209; in the strains 121 and *G* they were not recorded. Numerous experiments have shown that the quantity

of inoculum added to the selective medium is of great importance. If one adds too many parent cells, these acidify the medium and inhibit the growth of mutants, which require a neutral or slightly alkaline medium for their multiplication. If the parent cells are too few, the probability of occurrence of mutants among them is negligible.

Mutant staphylococci isolated by the new technique show the same changes in respiratory activity which have been previously reported[2,5]. The respiratory coefficient is decreased by 40–60 per cent as compared to parent values, while the respiration is less sensitive to cyanide. The cytochrome pattern is also altered in the new mutants. Whereas normal staphylococci reveal three bands of cytochromes, a_2(630 mμ), a_1(600 mμ), and b_1(557 mμ), in mutants the band a_2 is not visible, either under usual conditions of observation or when liquid nitrogen with the subsequent devitrification is employed. Instead of band b_1, two new bands are observed in mutants, at 563 and 553 mμ, which are easily oxidized and reduced in the presence of succinate. In respect of splitting of b_1 band of cytochromes, the mutants of staphylococci with impaired respiration resemble the respiratory-deficient mutants of *E. coli*[5].

Further investigations have shown that mutants with respiratory deficiency in staphylococci differ from the parent culture in a number of important biochemical characters. It may be suggested that respiratory defects, as well as other hereditary metabolic alterations, can be related to some disturbances in the synthesis of deoxyribonucleic acid in mutant staphylococci.

Pigment. A characteristic feature of staphylococci with defective oxidation is their rose-orange intracellular pigment, which is lacking in cells of the parent culture. Mutants were cultivated on the nutrient agar and extracted by ethanol. The absorption spectra of the ethanolic solutions of pigments so obtained from nine different respiratory-deficient mutants of staphylococci were studied, and found to be very similar. Fig. 1 presents the data for pigment from the mutant No. 16, revealing a maximum optical density at 475 mμ. This observation points to the possibility that respiratory defects in mutant staphylococci are accompanied by some disturbances in the metabolism of flavins.

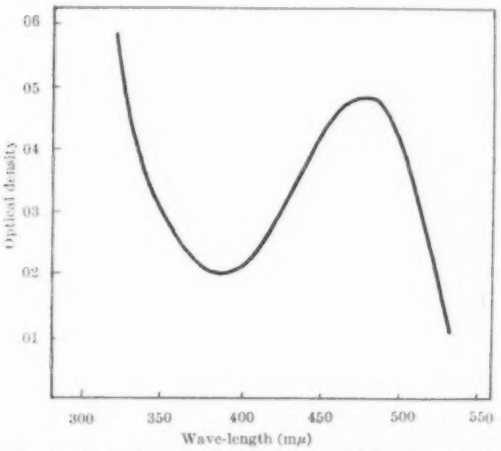


Fig. 1. Absorption spectrum of the intracellular pigment of mutant staphylococci with impaired respiration, strain No. 16

Synthesis of vitamin B_{12}. Theoretical considerations put forward by Woolley[6] suggest that alterations in flavins may affect the biogenesis of vitamin B_{12}. Experimental observations by the same author[7] indicate that respiratory defects and dedifferentiation of cells in some strains of spontaneous tumours of mice are accompanied by the ability of these cells to synthesize vitamin B_{12}.

The content of vitamin B_{12} in the cells of parent staphylococci as well as of a number of respiratory-deficient mutants, which were grown on the liquid medium under identical conditions, was measured with the aid of chromatographic and bioautographic techniques[8,9], using the culture of *E. coli* 113-3. The results of these measurements are presented in Table 2.

Table 2. Contents of Vitamin B_{12} in the Cells of Parent Staphylococci as well as in Respiratory-deficient Mutants

Strain	μgm./gm.	Strain	μgm./gm.
Parent 209	0·3	Mutant 21	18
Mutant 3	18	Mutant 1	26
Mutant 22	20	Mutant 2	17
Mutant 16	28	Mutant 20	23
Mutant 15	18	Mutant 14	16

It can be seen that the content of vitamin B_{12} in the cells of mutants may be increased almost a hundred-fold as compared to parent cells.

Catalase. Suspensions of staphylococci adjusted to 20 mgm./ml. dry weight were disrupted using a Mickle disintegrator at 0° C. and Ballotini glass balls No. 12. The catalase activities of the cell extracts were estimated spectrophotometrically[10]. Table 3 shows that respiratory-defective mutants contain much less catalase activity than the cells of the parent strain.

Table 3. Contents of Catalase (in Arbitrary Units) in the Cells of Parent Staphylococci and in the Respiratory-deficient Mutants

Strain	Catalase
Parent 209	4·02
Mutant 2	0·50
Mutant 21	0·56
Mutant 16	0·83

Amino-acid composition of the cell wall. Preliminary experiments carried out in collaboration with Drs. H. Rogers and H. R. Perkins showed a difference in cell wall composition between parent and mutant cells of staphylococci[11]. This observation has been confirmed using the new Park and Hancock[12] procedure, which was found to be very efficient. In hydrolysates of cell wall material of parent staphylococci, in accordance with the published evidence[13], the following components were recorded: alanine, glutamic acid, glycine, glycosamine, muramic acid and lysine. In mutants with impaired respiration (*uv*-2 and *uv*-3) only traces of lysine were recorded while diaminopimelic acid was observed. Since many bacteria possess the capacity to decarboxylate diaminopimelic acid into lysine[14], the substitution of lysine by diaminopimelic acid in the cell wall of respiratory-deficient mutants of staphylococci might indicate the loss by mutants of this specific decarboxylase. In the cell wall material of mutants were recorded also alanine, glutamic acid, glycine, glucosamine, muramic acid and aspartic acid.

Selective inhibition of the growth of mutants. In extension of earlier observations[15], a new series of alkylating agents, antimetabolites of nucleic acids,

Table 4. CONCENTRATIONS OF COMPOUNDS REQUIRED TO INHIBIT THE GROWTH OF PARENT STAPHYLOCOCCI AND RESPIRATORY-DEFICIENT MUTANTS ON NUTRIENT AGAR (μGM./ML.)

Compound	Parents 209	Mutants no 2 and 3
Miracil *D*	500	25
Triethylenemelamine	> 1,000	400
6-Mercaptopurine	> 1,000	30
6-Chloropurine	15,000	1,500
Mitomycin *C*	0·2	0·002
Actinobolin	100	12
Actidione	> 10,000	5,000
Streptomycin	2	10
Chlortetracycline	8	8
Tetracycline	2	2

and antitumour antibiotics was tested in relation to their possible selective inhibition of growth of the respiratory-deficient mutants (Table 4).

It can be seen that antitumour agents (in contrast to the antibiotics streptomycin and tetracyclines) selectively inhibit the growth of mutants with impaired oxidation.

It is interesting to record that the antitumour antibiotic mitomycin C inhibits the growth of mutants a hundred times more effectively than that of parents. The mechanism of action of this inhibitor on bacteria has been related to the selective damage to the synthesis of deoxyribonucleic acid[16].

In view of the fact that respiratory-deficient mutants of staphylococci differ from the parent organisms in a number of biochemical characters, a further analysis of the mechanisms of the selective inhibition of the growth of these mutants by antitumour compounds would be desirable.

Some of the observations reported in this article were started at the time of tenure by one of us (G. F. G.) of the World Health Organization fellowship at the National Institute for Medical Research, London. The senior author is grateful to Sir Charles Harington for hospitality and to Mr. J. W. Lightbown for many helpful discussions.

[1] Lindegren, C., *Nature*, **184**, 397 (1959).
[2] Gause, G. F., Kochetkova, G. V., and Vladimirova, G. B., *Doklady Acad. Sci. USSR*, **117**, 720 (1957).
[3] Gause, G. F., Kochetkova, G. V., and Sorbaeva, N. A., *Doklady Acad. Sci. USSR*, **130**, 200 (1960).
[4] Cohen, S., Flaks, J., Barner, H., Loeb, M., and Lichtenstein, J., *Proc. U.S. Nat. Acad. Sci.*, **44**, 1004 (1958).
[5] Gause, G. F., Ivanitskaia, L. P., and Vladimirova, G. B., *Doklady Acad. Sci. USSR*, **118**, 189 (1958).
[6] Woolley, D., *Antimetabolites and Cancer*, 163 (Washington, 1954).
[7] Woolley, D., *Proc. U.S. Nat. Acad. Sci.*, **39**, 6 (1953).
[8] Ford, J., Holdsworth, E., and Kon, S., *Biochem. J.*, **59**, 86 (1955).
[9] Verchovtseva, T., and Surikova, E., *Laboratornoe Delo*, **3**, 24 (1959).
[10] Chance, B., *Methods of Enzymology*, **2**, 764 (1955).
[11] Gause, G. F., *The Search for New Antibiotics*, 48 (Yale Univ. Press, 1960).
[12] Park, J., and Hancock, R., *J. Gen. Microbiol.*, **22**, 249 (1960).
[13] Strominger, J., Park, J., and Thompson, R., *J. Biol. Chem.*, **234** 3263 (1959).
[14] Rhuland, L., *Nature*, **185**, 224 (1960).
[15] Gause, G. F., and Kochetkova, G. V., *Antibiotiki*, **5**, 62 (1960).
[16] Shiba, S., Terawaki, A., Taguchi, T., and Kawamata, J., *Nature*, **183**, 1056 (1959).

AN INVESTIGATION OF CLOSELY RELATED GAMMA-MYELOMA PROTEINS AND NORMAL MOUSE GAMMA-GLOBULIN BY PARTIAL ENZYMIC DEGRADATION AND STARCH-GEL ELECTROPHORESIS

By DR. BRIGITTE A. ASKONAS and DR. J. L. FAHEY*
National Institute for Medical Research, London, N.W.7

GAMMA-GLOBULIN as normally found in the serum of mammals is highly heterogeneous in its physico-chemical characteristics. Investigation of its chemical structure is hampered by the difficulty of obtaining γ-globulin fractions consisting of single molecular species. The serum γ-globulin is derived from a large number of cells in many sites throughout the body[1]. The γ-myeloma proteins produced by one of the transplantable plasma cell tumours, by contrast, although very similar to normal γ-globulin in most respects, appear to be limited to a small number of molecular species, probably produced by a single plasma cell clone and may therefore provide a simpler model for structural studies of γ-globulin.

The serum of C_3H mice bearing one of the transplantable plasma cell tumours (X5563) contains a high concentration of γ-myeloma protein[2]. By analysis on starch-gel electrophoresis, this γ-myeloma protein was found to consist of five distinct components which are indistinguishable immunologically and had the same molecular size, but varied in electric charge[3]. In an attempt to discover a basis for the difference between these closely related γ-myeloma proteins produced by a single plasma cell tumour and possibly to throw light on the complexity of normal γ-globulin, we had recourse to partial degradation of the proteins with papain and cysteine. Such treatment has been shown by Porter[4] to split rabbit antibody into fragments with sedimentation constants of 3·5 and molecular weights of 50,000–70,000.

Purification of proteins and papain treatment. Normal γ-globulin was prepared from concentrated C_3H mouse serum by zone electrophoresis on blocks of 'Geon 425' (British Geon, Ltd.) by the method described in ref. 5. This preparation contained γ-globulin, migrating more slowly than β-globulin[4]. The 5563 myeloma proteins were prepared from serum of tumour-bearing mice by chromatography on columns of DEAE cellulose[5] using a slow elution gradient from 0·015 *M* to 0·05 *M* potassium phosphate buffer, *p*H 6·5 (ref. 6). Since the components of the myeloma proteins vary by only small differences in charge, only partial separation of the globulin molecules can be achieved and fractions of mainly one component contained also small amounts of adjacent components.

The characteristics of the purified proteins on starch-gel electrophoresis are seen in Fig. 1. The striking spread of the normal γ-globulins over a wide area is an indication of their heterogeneity whereas the γ-myeloma proteins form well-defined bands varying in mobility. Fig. 1 shows the myeloma protein components (*a*–*e*) in serum from a mouse

* Present address: National Cancer Institute, Bethesda, Maryland.

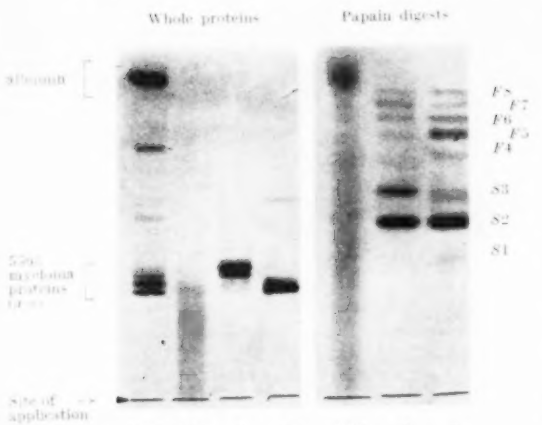


Fig. 1. Analysis by starch-gel electrophoresis. *NMy*, normal mouse γ-globulin was prepared by zone electrophoresis; myeloma proteins : 5563 myeloma protein components were prepared by chromatography on DEAE (ref. 6); components $a(+b)$ have a slight β-globulin contamination (band migrating faster); papain digests: purified *NMy* and 5563 myeloma protein components shown on left photograph were treated with cysteine and papain by the method of Porter (ref. 4)

bearing the 5563 tumour and the purified myeloma protein components $c + d$ and a + some b. The myeloma proteins and γ-globulin sedimented at the same rate ($S_{20,w}$ = 6·5) in the ultracentrifuge.

The purified proteins were treated with papain and cysteine as described by Porter[4], except that incubation with the enzyme at 37° was continued for 1 hr. only. The reaction went to completion in this time with more than 85 per cent of the protein recovered on weight basis, whereas longer periods of incubation resulted in losses of the split 5563 globulin. Analysis by ultracentrifugation was kindly carried out by Dr. P. Charlwood and showed that, as in the case of rabbit antibody[4], mouse γ-globulin and myeloma proteins were split into smaller molecules of S_{20} around 3·6.

Characterization of fragments in papain digests of purified proteins. The papain digests of normal γ-globulin and 5563 myeloma proteins were examined by immunoelectrophoresis against a mixed rabbit antiserum to normal γ-globulin and 5563 myeloma protein (Fig. 2). Treatment with papain and cysteine results in two types of fragments with distinct antigenic characteristics. Each digest gives two antigen–antibody precipitation arcs which cross. Similar results have been obtained with human γ-globulin (Edelman *et al.*[5]) and, for simplicity, these authors' nomenclature will be followed for the mouse globulin. The slowly migrating fragments (which move towards the cathode from the point of application) and the fast migrating fragments (which move towards the anode) have *S*- and *F*-antigenic grouping respectively. The observation that the precipitin arcs cross without interaction is taken to indicate that the *S* and *F* fragments have different structures and do not share any antigenic groupings.

Analysis by starch-gel electrophoresis revealed marked physicochemical heterogeneity of globulin fragments in the papain digests of these proteins (Fig. 1). The multiple well-defined protein bands, seen in the papain digests of the myeloma protein, are again in sharp contrast to the diffuse heterogeneity of the papain digest of normal γ-globulin. It also

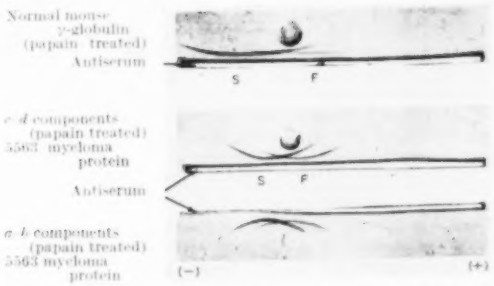


Fig. 2. Immunoelectrophoretic analysis of papain-treated proteins. The antiserum used was a mixture of antiserum to normal mouse γ-globulin and the 5563 γ-myeloma protein. The proteins had been treated with papain and cysteine by the method of Porter (ref. 4)

can be noted that the different myeloma protein components ($a(+b)$, $c + d$) yield fragments, some of which are identical and some of which differ qualitatively or are present in different quantities.

The papain digests were fractionated by chromatography on DEAE cellulose using gradient elution with potassium phosphate buffers of *p*H 8 (Fig. 3). Four protein peaks were obtained. These were concentrated by ultrafiltration and analysed by starch-gel electrophoresis and by gel diffusion in an Ouchterlony plate against antiserum to 5563 myeloma protein. As a result it was possible to classify the chromatographic protein fractions and the many physicochemically different fragments seen on starch-gel electrophoresis into two major groups (*S* and *F*) on the basis of their antigenic characteristics. Peaks S_1, S_2, S_3 (see chromatographic elution pattern, Fig. 3) were found to have the same antigenic groupings, giving reactions of identity when tested in a gel diffusion plate with antiserum to 5563 myeloma protein and normal mouse γ-globulin. This is shown for S_2 and S_3 in Fig. 4. The chromatographic peak *F*, however, had distinct antigenic grouping. Its antibody–antigen precipitation line crossed that of the S_3 fragment on an Ouchterlony diffusion plate (Fig. 4). Starch-gel electrophoresis revealed that chromatographic peaks S_1, S_2 and S_3 contained

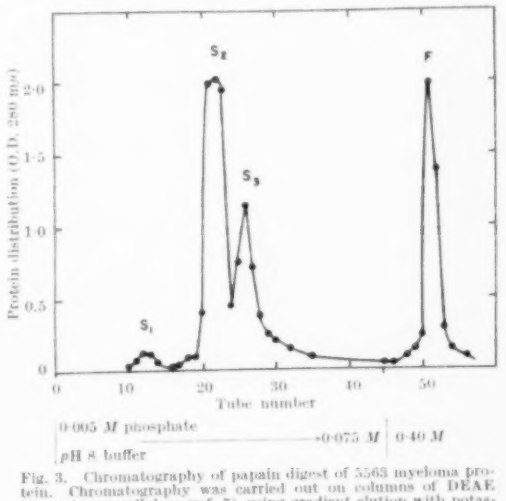


Fig. 3. Chromatography of papain digest of 5563 myeloma protein. Chromatography was carried out on columns of DEAE ion-exchange cellulose (ref. 7), using gradient elution with potassium phosphate buffer *p*H 8 as indicated on the graph. 3-ml. fractions were collected

Table 1. SEDIMENTATION CONSTANTS

	S_{20}	
	Whole protein	Papain digest
Normal γ-globulin	6·5	3·86
5563 Myeloma protein (components *a–d*)	6·6	3·62
Papain digest 5563 myeloma protein		
S_2		3·73
S_3		3·71
F_5–F_8		3·51

The sedimentation constants were kindly determined by Dr. P. Charlwood on samples extensively dialysed against saline-phosphate buffer, pH 7·4 at concentrations of 0·3–0·6 per cent (w/v).

starch-gel bands S_1, S_2 and S_3, respectively. Peak F, however, consisted of a number of fragments in the F_5–F_8 positions on starch-gel electrophoresis. Table 1 shows that the fragments S_2, S_3 and F had very similar sedimentation constants in the ultracentrifuge (S_{20} = 3·5–3·7).

Comparison of different 5563 *myeloma proteins.* It was mentioned earlier that plasma cell tumour 5563 secretes γ-myeloma proteins consisting of five components (*a–e*) which have slightly different mobilities on starch-gel electrophoresis. The difference in electrical charge between 5563 myeloma molecules *a* and *d* must be at least 3 single or multiple charge units in view of the regularity in increase of mobility. The separated components on treatment with papain and cysteine break down to fragments giving different patterns on starch-gel electrophoresis (Fig. 1). For purposes of discussion only fragments composing more than 5 per cent of the total protein will be considered. Papain digest of 5563 myeloma protein *a* (+ *b*) will be considered first. The starch-gel pattern shows a strong band in position S_3—there is a weak band migrating more slowly than S_3 which is due to contamination of the original myeloma protein with β-globulin. There are four bands, F_4–F_8, with *F*-antigenic grouping which migrate faster than the *S* bands. An approximate estimate of the quantity of different fragments may be obtained by making the starch-gel transparent and staining in glycerol by the method in ref. 9. The colour intensity of the bands is measured by a recording microdensitometer. This method tends to under-estimate the relative amount of fragment S_2 present in high concentration and over-estimate the minor components (F_4–F_8). Similar estimates were made by calculating recovery of different protein fragments from the chromatographic elution patterns (Fig. 3). The combined estimations are seen in Table 2. Both methods are very approximate, but indicate that fragment S_2 represents about two-thirds of original globulin molecule and fragments F_5–F_8 one-third. Myeloma protein *a* (+ *b*), on treatment with papain and cysteine, thus splits into a single fragment (S_2) with *S*-antigenic grouping (two-thirds of total protein) and a number (four) of fragments with *F*-antigenic grouping representing roughly one-third of the original protein.

The papain digest of myeloma proteins *c* + *d* shows a slightly different pattern on starch-gel electrophoresis (Fig. 1) and yields two fragments with *S*-antigenic grouping, one in the same position as S_2 and a fragment with greater mobility, S_3. In addition, four or five fragments with *F*-antigenic grouping can be observed. They are present in different quantities from those in the papain digest of myeloma protein *a* (+ *b*). A quantitative estimate of the relative amounts of papain fragments shows that we have about 36 per cent of S_2 and 20 per cent of S_3. Fragment S_2 and fragment S_3 with *S*-antigenic grouping represent about two-thirds of the original myeloma protein, whereas the *F*-fragments (F_5–F_8) represent about one-third (Table 2). Table 2 also

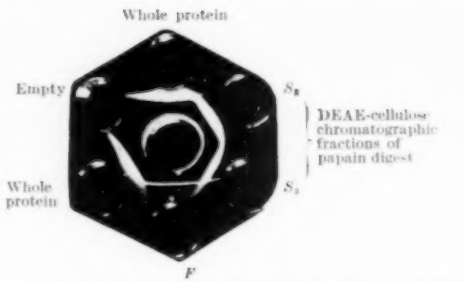


Fig. 4. Antigenic comparison of papain fragments of 5563 myeloma protein by agar diffusion. Centre cup, rabbit antiserum against 5563 myeloma protein; antigen was present at a concentration of 0·2 mgm. protein/ml. Whole protein refers to 5563 myeloma protein purified by DEAE exchange cellulose (ref. 3). Fractions S_2, S_3 + F were prepared from 5563 myeloma protein treated with papain and cysteine by chromatography on DEAE (Fig. 3)

shows the relative distribution of fragments when myeloma proteins *b* + *c* with intermediary electrophoretic mobilities are treated with papain and cysteine. In this case 15 per cent of fragment S_3 is formed. The ratio S_2/S_3 thus decreases, when myeloma proteins *a*,*b* + *c*, and *c* + *d* are broken down, but the yield of total fragments with *S*-antigenic groupings stays constant and represents roughly two-thirds of the original protein (65–72 per cent by our estimations). Once more the relative amount of total fragments with *F*-antigenic grouping stays constant representing 28–35 per cent and being about one-third of the original protein molecule. The relative concentrations of *F*-fragments with different mobilities vary—when the faster migrating myeloma proteins are degraded higher concentrations of faster migrating *F*-fragments appear. The mobility of the original myeloma proteins thus appears to depend on variation in electric charge in both the fragments with *S*- and *F*-antigenic groupings.

In general these results agree with the results obtained by Porter[1], which suggested that rabbit antibody globulin split into three fragments roughly one-third the size of the original molecule. The 5563 myeloma protein, on treatment with papain and cysteine, appears also to split into thirds, two fragments with *S*-antigenic grouping and one fragment with *F*-antigenic grouping. The slowest migrating myeloma protein yields a single *S*-fragment (S_2) two-thirds of the original protein, but a number

Table 2. ESTIMATE OF RELATIVE AMOUNTS OF PROTEIN FRAGMENTS RESULTING FROM PAPAIN AND CYSTEINE TREATMENT OF 5563 MYELOMA PROTEINS

Myeloma proteins treated with cysteine and papain	*a* (+ *b*)	*b* + *c*	*c* + *d*
Papain digest fragments	Per cent of total protein		
S_2*	52·5	46·5	33·5
S_3*	5·6	19·5	22
F_5*	21	14·6	7·3
F_6*	10·4	13	13·6
F_7*	7·3	3	14·2
F_8*	2·7	3	9·5
S_2†	67	55	36
S_3†	5	15	29
Total *S*†	72	70	65
Total *F*†	28	30	35
Ratio total *S*/*F*†	2·5	2·3	1·9
Ratio S_2/S_3†	13·4	3·6	1·2

* Values are approximate and based on measurement of colour intensity of stained protein bands after electrophoresis on a starch-gel block stained in glycerol (ref. 9). This method is known to underestimate the components present in high concentration compared with those present in smaller amounts.

† Values based on protein elution pattern resulting from chromatography of papain digests on DEAE cellulose (Fig. 3). This method is quantitatively more reliable, but does not distinguish the different *F*-components.

of F-fragments (varying in mobility on starch-gel electrophoresis). Myeloma proteins with increasing electrophoretic mobility yield S_2 and increasing amounts of fragment S_3, which migrates faster than S_2, but the total amount of $S_2 + S_3$ remains constant. A quantitative variation in the F-fragments is also observed when myeloma proteins with increasing mobility are degraded. A single difference between S_2 and S_3 could not account for five original myeloma components, and it is therefore likely that there are also variations in the F-portion of the molecule. It remains to be seen whether the multiplicity of the F-fragments resulting from myeloma protein $a(+b)$ are a consequence of progressive enzymic digestion of a single F-fragment or whether a single myeloma protein band can contain different molecular fragments with F-antigenic grouping to start with. The gradual loss of fragments with F-antigenic grouping, if incubation with cysteine and papain is continued for more than 1 hr., may support the first possibility. This point and the difference between S_2 and S_3 are being investigated further.

We are indebted to Dr. P. Charlwood for determinations of sedimentation coefficients by ultracentrifugation, to Dr. M. Potter for sending us the 5563 plasma cell tumour line, and to Dr. R. K. Porter and Dr. J. W. Goodman for a gift of papain. We should like to thank Dr. R. R. Porter and Dr. J. H. Humphrey for helpful discussions, and Mrs. Marion Perryman for her assistance.

[1] Askonas, B. A., Humphrey, J. H., and Porter, R. R., *Biochem. J.*, **63**, 412 (1956).
[2] Potter, M., Fahey, J. L., and Pilgrim, H. I., *Proc. Soc. Exp. Biol. and Med.*, **94**, 327 (1957).
[3] Askonas, B. A., *Biochem. J.*, **79**, 33 (1961).
[4] Porter, R. R., *Biochem. J.*, **73**, 119 (1959).
[5] Fahey, J. L., and Horbett, A. P., *J. Biol. Chem.*, **234**, 2645 (1959).
[6] Fahey, J. L., and Askonas, B. A. (in preparation).
[7] Peterson, E. A., and Sober, H. A., *J. Amer. Chem. Soc.*, **78**, 751 (1956).
[8] Edelman, G. M., Heremans, J. F., Heremans, M. Th., and Kunkel, H. G., *J. Exp. Med.*, **112**, 203 (1960).
[9] Gratzer, W. B., and Beavan, G. H., *Clin. Chim. Acta*, **5**, 577 (1960).

RESPIRATORY EFFECTS OF PHOSPHORYLATION

By Prof. H. LUNDEGARDH
Penningby, Sweden

OXIDATIVE phosphorylation is the main mechanism for transfer of energy from the respiratory system by converting adenosine diphosphate (ADP) to adenosine triphosphate (ATP)[1-15]. The reaction

$$\mathrm{ADP} + \mathrm{PO_4} + \text{energy} \rightleftharpoons \mathrm{ATP} \qquad (1)$$

is controlled by a number of enzymes, enabling ATP to transfer energy to many synthetic processes in the protoplasm. In oxidative phosphorylation the supply of energy on the left side of equation (1) is delivered by the stream of electrons moving from an enzyme of lower oxidation potential to an enzyme of higher potential (the difference is 0·17 V. for a two-electron process). ATP and similar compounds are thus serving as the main energy-distributing system, the inhibition of which leads to rapid degradation of the living structure.

The mechanism of oxidative phosphorylation is still incompletely known. It has been claimed that the energy from a flow of electrons between a donor (B) and an acceptor (A) may be transferred to ATP over an intermediate reaction[2-4,15]. Phosphate may, at a low expense of energy, be combined with one of the enzymes, for example, as $B - \mathrm{PO_4}$, and then, on oxidation by A, be transferred to the high-energy state of ATP. Another possibility is phosphorylation by means of an intermediate substance, for example, a quinone[2]. It is postulated in both cases that the electrons are transferred from B to A through intermediate reactions. Even if other more direct pathways of transfer between A and B exist, phosphorylation would consequently serve as an accelerator of the stream of electrons through the respiratory system. This suggests the possibility of observing the effect of phosphorylation and the possible sites of this process by measuring the apparent reaction velocities of the enzymes involved.

A suitable technique has been developed on the basis of new spectrophotometric methods for accurate measurement of the time-course of reduction and reoxidation of all respiratory enzymes[7,10,11]. These methods may be applied to live intact tissues or cell suspensions. Owing to the inevitable partial invalidation of the respiratory unit, particulate fractions of homogenates are less suitable for these studies. The present article deals with oxidative phosphorylation in bakers' yeast. The experimental technique was based on the reversibility of the steady-state reaction (1). It was shown[8] that, in wheat-roots, supply of inorganic phosphate promotes an increasing reduction of the cytochromes, whereas the level of oxidation is raised by addition of ATP (ref. 8). These results were interpreted in terms of a displacement of the steady-state equation (1) by an increase or a decrease of concentration of the reactants. Nucleotides penetrate the protoplasm easily. Application of ADP + phosphate or of ATP to a yeast suspension affects the course of electron transfer in less than 3 min.

The experiments were conducted as follows: Bakers' yeast (from Svenska Jästfabriks AB) is thoroughly washed and 16 ml. of a 5–10 per cent suspension is introduced into a quartz circulation vessel[9,11]. The recipient is placed immediately in front of an *EMI* quartz photomultiplier tube 6256 connected to a Philips oscilloscope *GM* 5666. By means of a special electromechanical device[11], which moves the wave-length screw of a Bausch and Lomb grating monochromator rapidly between two end-intervals[11,12], a suitable portion of the spectrum is recorded in a Zeiss Frequentophot camera. The bands of cytochromes c (550 mμ) and b (562 mμ) are directly visible on the record[12]. Other band-peaks (diphosphopyridine nucleotide (DPNH) 340, flavoprotein (FP) 465, cytochromes a_3 444 and 598, c_1 554, and a 604 mμ) are caught by means of a mechanical device which interrupts the oscillographic image at these wave-lengths[11].

Precise measurements of band-heights postulate intimate knowledge of spectral coincidences and of the spectra of purified enzymes[9,11,12]. The time-course of the reduction of the enzymes at stopped aeration (or shifting over to nitrogen) and the reoxidation in air (or oxygen) may be varied, owing to the degree

of exhaustion of respiratory substrates in the washed yeast, and the level of temperature, etc. Reduction of the respiratory enzymes is completed in a few seconds at 18° C., but reoxidation may sometimes take only 1–2 sec. Experience has shown that a speed of 4 spectrograms per sec. in all circumstances secures a reliable calculation of the half-times (ht = 50 per cent reaction) of reduction and reoxidation. The apparent velocity is calculated as c/ht (c = reacting portion of the enzyme).

A new technique was introduced for measuring the intensity of respiration during the single experiments. It was shown in this laboratory that the time-lag between turning off the air stream and the start of reduction of the cytochromes $c - a_3$ is inversely proportional to the velocity of respiration, provided that the periods of aeration are held constant. This demand is fulfilled by the introduction of a timer which, by means of electromagnetic valves, regulates the intervals of aeration (15 sec.) and stopped air-flow (mostly 75 sec.). Processes which are not directly linked to the respiratory chain are eliminated by the intermittent aeration.

At the start of the single experiments the apparent velocities of reduction and reoxidation in distilled water were recorded. Immediately following the start, the test substance was added to the recipient. The response was automatically recorded in 4, 6, 10, 16 min.

Results

Addition of ADP, with or without phosphate (the latter is always present in yeast cells), results in an increase of the respiration (Fig. 1), the maximum of which is attained in 3–4 min. As shown in Table 1, the respiratory effect is caused by an acceleration of the stream of electrons, namely, an increased velocity of reduction of the group $a_3 - c$ and of DPN. This increased reduction conveys a corresponding retardation of the reoxidation, because the off-reaction of cytochrome oxidase, namely, the transition $a_3 \overset{e}{-} O_2$ remains approximately unaffected. Measurements show this to be the case (cf. Figs. 1, 2). As a consequence of the increased internal supply of

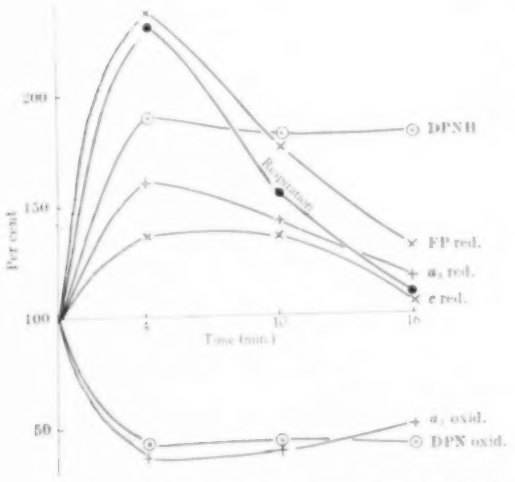


Fig. 1. Response of respiration and apparent velocities ($1/ht$) of reduction and reoxidation on addition of 0·01 M ADP + phosphate to a yeast suspension

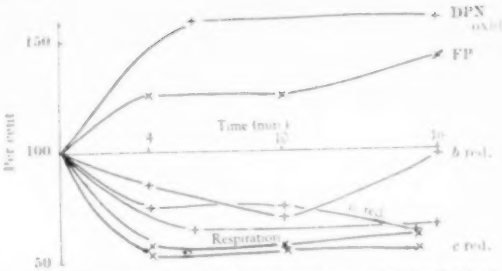


Fig. 2. Response of respiration and apparent velocities ($1/ht$) of reduction and reoxidation on addition of 0·01 M ATP to a yeast suspension

electrons at constant velocity of the transference $a_3 \overset{e}{-} O_2$, the cytochromes c and a_3, and flavoprotein are 20–40 per cent more reduced in the aerobic state whereas cytochrome b and DPN remain more unaffected. The balance between oxidized and reduced enzyme is determined by the relation $k_1 k_2$ in the sequence:

$$\overset{e}{-} \text{enzyme} \underset{k_2}{\overset{k_1}{-}} \overset{+}{-}$$

on-reaction off-reaction

k_1 and k_2 represent the velocities of the on- and off-reactions.

The fact that the step $a_3 \overset{e}{-} O_2$ does not respond to ADP leads to the conclusion that this step is not involved in phosphorylation. The only known case of an actual acceleration of the stream of electrons from cytochrome oxidase to oxygen is the salt effect, the nature of which has been discussed elsewhere[10,13,14]. Another important difference between the effects of ADP and salts is the response of cytochrome b. In contrast to the uniform response of the total chain of enzymes to salts, glucose and alcohol, ADP reveals a segregation inasmuch as the reduction of cytochrome b is not accelerated.

This individual behaviour of cytochrome b does not mean, however, that it is bypassed by the electrons. An intensification of the stream of electrons between b and $c - a_3$ creates a 'vacuum' at b, appearing as a relatively retarded reduction. The observed facts are leading to the conclusion that the transition $b \overset{e}{-} c$ is one of the main sites of oxidative phosphorylation. Cytochromes c and a_3 are, as previously shown[12], closely linked together kinetically and the observed identical response of these two enzymes (Table 1) leaves little room for intermediate reactions.

The response of flavoprotein to variations in the ADP/ATP balance is not identical with that of

Table 1. Change of the Relative Velocity of Reduction (at stopped Aeration) 3–6 min. after Addition of 100 mgm. ADP or ATP (Disodium Salt), corresponding to Concentration of 0·01 mole/l. ht = time of 50 per cent Reaction (sec.)

	Cyt. a_3	Cyt. c	Cyt. b	Flavo-protein	DPN
$1/ht$ in water	0·36	0·38	0·22	0·23	0·06
Response on ADP	0·61 (+ 68 per cent)	0·60 (+ 57 per cent)	0·13 (− 42 per cent)	0·29 (+ 26 per cent)	0·13 (+ 84 per cent)
Response on ATP	0·23 (− 37 per cent)	0·27 (− 30 per cent)	0·20 (− 9 per cent)	0·13 (− 42 per cent)	0·04 (− 31 per cent)

Similar values are obtained 10–12 min. after addition of the reagents.

cytochrome *b*. It was shown earlier that flavoprotein sometimes acts simultaneously with cytochrome *b* and that one fraction of it may be linked structurally to the latter[12]. The total flavoprotein is, on the other hand, distributed over at least two enzyme systems, of which one is identical with succinodehydrogenase. This fact may explain the rather varying response of flavoprotein in the present experiments. The results are, however, not opposed to a possible site of phosphorylation near flavoprotein (for the effect of succinate oxidation on phosphorylation see ref. 16).

DPN is known to participate in a large number of enzyme reactions. Table 1 shows a strong acceleration of the step substrate $\overset{c}{\text{—}}$ DPN under the influence of ADP and a corresponding retardation by ATP; these facts illustrate the well-known role of substrate oxidation by DPN in oxidative phosphorylation.

The theoretically expected reversal effect of ATP, as compared with ADP, is illustrated by the steady-state equation (1) (Table 1 and Fig. 2). Addition of ATP retards the transport of electrons from substrates to DPN and from cytochrome *b* to *c*. Consequently, the aerobic respiration declines. Values of only 50 per cent of that in distilled water were observed (Fig. 2). The steady-state oxidation — reduction of respiratory enzymes in aerated yeast, treated with ATP, shows an increasing oxidation, primarily, of DPN and the cytochromes *b* and a_3.

2,4-dinitrophenol (DNP) inhibits phosphorylation, but it acts, nevertheless, similarly to ADP. It accelerates the electron transfer from cytochrome *b* to the group $c - a_3$ (Table 2 and Fig. 3). This fact indicates a competitive effect of DNP, namely, this substance is obviously capable of transferring electrons between *b* and $c - a_3$, as a consequence of which the respiration may be raised above the level held in distilled water.

It is interesting to note that the 'vacuum' at cytochrome *b* is observed also with DNP, a fact emphasizing the probable competitive interaction of this substance in the phosphorylation mechanism. Attention is here again directed to the fundamentally different effect of salts.

Table 2. Effect of $1{\cdot}3 \times 10^{-4}$ *M* 2,4-Dinitrophenol (DNP) and further addition of $1{\cdot}3 \times 10^{-4}$ *M* Potassium Chloride (DNP + Potassium Chloride) on Respiration and Kinetics of Enzyme Reactions

A. Reduction at stopped aeration

Medium	Respiration (relative)	Apparent velocities ($1/\Delta t$ sec.)		
		a_3	*c*	*b*
Water	100	0·36	0·38	0·22
DNP 10 min.	125 (+ 25 per cent)	0·45 (+ 25 per cent)	0·51 (+ 34 per cent)	0·28 (+ 27 per cent)
DNP + potassium chloride 10 min.	167 (+ 67 per cent)	0·63 (+ 75 per cent)	0·57 (+ 50 per cent)	0·39 (+ 77 per cent)

B. Reoxidation in air

Medium	Apparent velocities ($1/\Delta t$ sec.)		
	a_3	*c*	*b*
Water	0·63	1·00	1·00
DNP 10 min.	0·78 (+ 23 per cent)	1·07 (+ 7 per cent)	0·85 (− 15 per cent)
DNP + potassium chloride 10 min.	1·30 (+ 106 per cent)	1·26 (+ 26 per cent)	1·55 (+ 55 per cent)

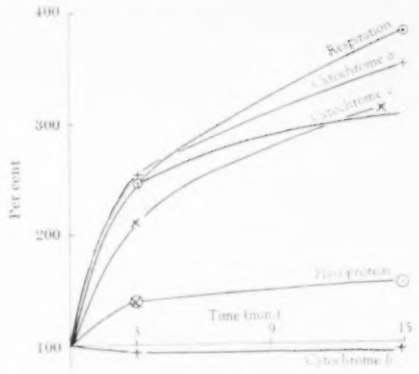


Fig. 3. Response of respiration and apparent velocities of reduction ($1/\Delta t$) on addition of $1{\cdot}3 \times 10^{-4}$ *M* 2,4-dinitrophenol

Salts are obviously promoting an unspecific electron transference through the respiratory chain, primarily by facilitating the passage of electrons from a_3 to oxygen. Table 2 illustrates the important fact that the salt effect may be superimposed on the DPN effect, resulting in an over-powered electron transfer, which is suggested by a further rise of the respiration.

The unspecific stimulation by salts (electrolytes) produces no vacuum at cytochrome *b* (Table 3). Salts obviously stimulate both the more direct transfer of electrons and, by indirect stimulation, of $\overset{e}{a_3} - O_2$, also the oxidative phosphorylation. This was concluded in previous investigations on the mechanism of absorption and accumulation of salts[10].

Table 3. Effect of Inorganic Phosphate as compared with ADP + Phosphate on the Apparent Velocities of Reduction Values in percentage of those observed with water (cf. Tables 1 and 2)

Medium	a_3 (per cent)	*c* (per cent)	*b* (per cent)	Flavoprotein (per cent)
Potassium phosphate (0·02 *M*; *p*H 6·2)	+ 68	+ 41	+ 98	+ 50
0·01 *M* ADP + phosphate	+ 68	+ 57	− 42	+ 26

Discussion

The results are in agreement with other work[2-4,14] on phosphorylation by means of intermediate reactions between two respiratory enzymes. Because these reactions are transferring electrons, oxidative phosphorylation acts similarly to a lowering of the internal resistance to the stream of electrons flowing through the system. The organized respiratory unit is envisaged here as a semiconductor, in which electrons are forwarded by means of exchange reactions between atoms and groups of atoms. Reversal of the concentration gradient ADP + phosphate > ATP acts similarly to an increase of the internal resistance, because the intermediate reactions are slowed down according to the law of mass action.

It has sometimes been claimed that two respiratory enzymes which are co-operating in oxidative phosphorylation do not react directly with one another[4]. This idea is at variance with the present experiments.

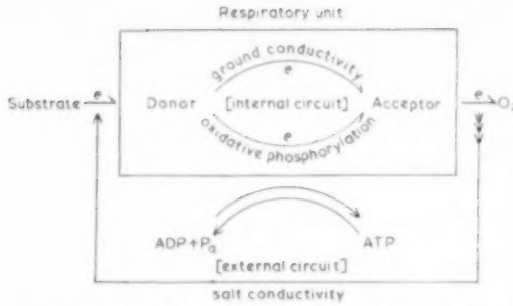


Fig. 4. Scheme of the inner and outer electric circuits in which the flow of electrons is in part controlled by the intensity of oxidative phosphorylation, namely, the activity relations of ADP and ATP, and by the activity of salts in the area surrounding the respiratory unit

My results point to the existence of other eventually more direct pathways, also, which, however, are insufficient for the maintenance of a maximum rate of respiration. There is, of course, a possibility that energy-saving mechanisms other than phosphorylation are co-operating in this 'ground conductivity' of the space between two respiratory enzymes.

The kinetic characteristics of the respiratory unit suggest the conclusion that the enzymes are organized as multimolecular sub-units which, owing to the structurally guided electron transference, are reacting at special points ('reaction centres') or surfaces[12]. This means that the electrons may be sluiced between two enzymes via intermediate processes ('factors') which are mediating the contact. When the supply of oxygen is stopped, the cytochromes c and a_3 start reduction (Table 1). The reduction of cytochrome b starts only after cytochrome c is almost reduced.

It was assumed that the multimolecular sub-unit $c - a_3$ is attached to cytochrome b at only one point or surface and that this area of contact remains oxidized until the $c - a_3$ complex is nearly saturated by electrons[12]. Switching on oxidative phosphorylation accelerates the process. My results convey the conclusion that the transference $b \xrightarrow{e} c$ is one of the main sites of oxidative phosphorylation, whereas the step $a_3 \xrightarrow{e} O_2$ does not participate directly.

The characteristic qualities of oxidative phosphorylation and of salts (electrolytes) in promoting the electron transfer through the respiratory system are shown in Fig. 4. Unlike DNP, which to some extent can substitute ADP in the intermediate electron transfer, salts do not compete with phosphorylation. Salts, on the contrary, act indirectly as powerful promoters of phosphorylation, mainly because the step $a_3 \xrightarrow{e} O_2$, which responds promptly to an increase of electrolytic conductivity, controls the total flow of electrons through the system.

The respiratory unit operates similarly to an electric generator[13], built on the basis of semiconductivity. An internal stream of electrons flows from the substrate to oxygen. The overall intensity (electronic density) of the stream is controlled by the electric conductivity of the outer circuit, namely, primarily the concentration (activity) of easily movable salt anions in the surroundings of the system. Salts accelerate non-specifically all internal pathways of electrons, hence the total aerobic respiration. The readiness of the substrate to deliver electrons is, of course, a fundamental regulator of respiration too, but it does not, unlike salts, affect the end-oxidation, namely, the velocity of the step $a_3 \xrightarrow{e} O_2$.

Salts thus regulate the external resistance to aerobic respiration, and oxidative phosphorylation implies an important regulator of the internal resistance. According to the scheme in Fig. 4, salts also accelerate the electrons which enter the respiratory system from the substrate side. Whereas yeast and animal cells are characterized by only one main exit of electrons, namely, at cytochrome a_3, there are at least two points of admission, but facts as to the biochemical pathways are here still incomplete. We know that the respiratory enzymes are more or less intimately bound to the cell structure, a_3 and b, very firmly, and c and flavoprotein somewhat more loosely. DPN is one of the most versatile co-enzymes. It is possibly synthesized in the nucleus[8] and moves around freely. My results on the acceleration of electrons from the substrate to DPN by ADP + phosphate illustrate the well-known fact that sites of phosphorylation are located between DPN and the substrates.

The investigation has been supported by the Swedish Research Councils of Natural Science and Agriculture.

[1] Lehninger, A. L., *Harvey Lectures Ser.*, **39**, 176 (1955).
[2] Clark, V. M., Kirby, G. W., and Todd, A. R., *Nature*, **181**, 1650 (1958).
[3] Lindberg, O., Grabe, B., Löw, H., Slekevitz, P., and Ernster, L., *Acta Chem. Scand.*, **12**, 598 (1958).
[4] Glahn, P. E., and Nielsen, S. O., *Nature*, **183**, 1578 (1959).
[5] Slater, E. C., *Proc. Intern. Symp. Enzyme Chem., Tokyo and Kyoto*, 288 (1957).
[6] Morton, R. K., *Nature*, **181**, 540 (1958).
[7] Lundegårdh, H., *Ark. Kemi (Stockholm)*, **5**, 97 (1953).
[8] Lundegårdh, H., *Physiologia Plantarum*, **8**, 142 (1955).
[9] Lundegårdh, H., *Biochim. Biophys. Acta*, **20**, 469 (1956).
[10] Lundegårdh, H., *Physiologia Plantarum*, **11**, 332, 564, 585 (1958); **12**, 1, 342 (1959).
[11] Lundegårdh, H., *Endeavour*, **18**, 191 (1959).
[12] Lundegårdh, H., *Biochim. Biophys. Acta*, **35**, 340 (1959).
[13] Lundegårdh, H., *Nature*, **185**, 70 (1960).
[14] Lundegårdh, H., *Pflanzenphysiologie* (Gustav Fischer, Jena, 1960).
[15] Lehninger, A. L., Wadkins, Ch. L., and Reumert, L. F., *Ciba Foundation Symposium, Regulation of Cell Metabolism*, 130 (1959).
[16] Greengard, P., Minnaert, K., Slater, E. C., and Betel, J., *Biochem. J.*, **73**, 637 (1959).

COLICINE FACTORS AS FERTILITY FACTORS IN BACTERIA

Salmonella typhimurium strain LT2

SALMONELLA TYPHIMURIUM strain *LT2* does not form and is not killed by colicines *E1*, *E2*, *I* or *K*[1,2]. However, it can be made colicinogenic for any of these colicines by growth in mixed culture with an appropriate colicinogenic strain of Enterobacter, presumably as a result of the transfer of a genetic element (colicine factor) controlling the production of a particular colicine. Colicine factor *I* (determining production of colicine *I*), when introduced into *S. typhimurium*, strain *LT2*, can be transmitted by cell contact to other sub-lines of strain *LT2*; and it also potentiates the transmission o colicine factors *E1*, *E2* and *K* which, in *S. typhimur*

ium, are not otherwise transmissible by cell contact (or, in the case of factor *E*1, only at a very low frequency). We report here that in *S. typhimurium*, strain *LT*2, factor *I* also makes possible recombination of chromosomal characters following cell conjugation, although the frequency is very low (10^{-6}–10^{-5}) compared with the frequency of transfer of colicinogeny (10^{-1}).

In a broth culture of an *LT*2 sub-line which has carried factor *I* for some time, only a small fraction (1/6,000) of the cells can transmit colicinogeny by cell contact[1]. However, Stocker and Smith[2] found that just after acquiring factor *I*, most cells transmit not only this factor but also any other factors the cell may possess. The increased ability to transmit persists for only 3–7 generations. In recombination experiments, therefore, the bacteria of the parent strain intended as 'donor' of colicinogeny had to be newly infected with factor *I* by growing them with cells possessing this factor. For example, when the donor strain was to be *cys D*-36 (an auxotrophic sub-line of strain *LT*2 requiring cysteine), it was infected with factor *I* by inoculating broth with about 10^8 cells/ml. of *cys D*-36 and about 5×10^4 cells/ml. of *cys D*-36 (*I*), that is, the same strain already carrying factor *I*. After overnight incubation at 37° C., the mixture was diluted 1/10 in fresh broth and incubated for 2 hr. at 37° C.; during this period, about 40 per cent of *cys D*-36 cells newly acquired factor *I* and, consequently, were all able to transmit it.

This 'donor mixture' was then incubated for 1 hr. at 37° C. with an equal number of acceptor cells (for example, *ath C*-5, a sub-line of strain *LT*2 requiring adenine + thiamine) and washed samples plated on unsupplemented glucose–ammonium sulphate medium to detect prototrophic (*cys D*$^-$ *ath C*$^+$) recombinants. About one prototrophic colony was formed for 10^8 cells plated, whereas control platings (*cys D*-36 alone; *ath C*-5 alone; and mixture of non-colicinogenic *cys D*-36 and *ath C*-5) gave either no colonies, or a significantly smaller number attributable to reversion. If the *cys D*-36 component of the donor mixture was replaced by the same strain carrying colicine factor *E*1 (*cys D*-36(*E*1)), the yield of recombinants was increased about one hundred-fold. The presence of factor *E*1 in the acceptor strain, however, has little or no effect on the yield of recombinants. Also, factor *E*1 did not permit recombination in the absence of factor *I*. Thus, the presence of factor *E*1 in the donor strain increases the rate of recombination when factor *I* is being transmitted, but does not by itself permit recombination.

The *cys D*-36 (*I*) minority component of the donor mixture, used to introduce factor *I* into the majority component *cys D*-36 (or *cys D*-36 (*E*1)), could be replaced by strain *ath C*-5 (*I*) without reduction of the yield of recombinants. This and other experiments showed that the *ath C*$^+$ genes of the recombinants came from the strain of the donor mixture initially lacking factor *I*; presumably from bacteria which had just acquired this factor.

Recombinants were obtained, at about the same frequencies, from crosses involving acceptor strains carrying many different contra-selective markers (*ade A*, *B* and *C*; *ath C* and *E*; *ara*; *cys A*, *B*, *C* and *D*; *gly*; *his*; *isol*; *leu*; *pro*; *thr*; *try A* and *D*; *str-s*). In fact, positive results were obtained for all loci tested. Pairs of genes which can be simultaneously transduced by phage *PLT*22, for example, *try D* and *cys B*, remain coupled more frequently than they do during phage-mediated transduction.

Differing donor alleles occupying two or more loci which cannot be simultaneously transduced by phage *PLT*22 are found together in recombinants formed during transfer of colicine factors too frequently for them to have been transferred separately to the same donor cell in different mating events. For example, either *ara* or *isol* occurs separately at a frequency of 10^{-7}, while together, they occur at 10^{-5}. This suggests that long portions of the bacterial chromosome can recombine; perhaps, at least in some cell-pairs, the entire chromosomes of the two pairing bacteria.

Colicine factor *I* was introduced into our sub-lines of *S. typhimurium*, strain *LT*2, by growth with *Shigella sonnei*, strain *P*9, and factor *E*1 by contact with *Escherichia coli*, strain *K*12–30 (both strains were kindly supplied by Prof. P. Fredericq, of Liège). Furness and Rowley[4] found that most wild strains of *E. coli* which produced colicine *I* carried *F* (fertility) factors which, however, could be separated from their colicine factors. We considered the possibility that our colicinogenic *S. typhimurium* strains could recombine because they had acquired *F* factors at the same time as colicine factors; but our colicinogenic *LT*2 strains do not recombine like *LT*2 strains carrying an *F* factor from *E. coli* (Zinder[5] and personal communication).

All the recombinants which have been analysed have been stable, and are thus presumably haploids produced by segregation after chromosomal recombination in a (transient) zygote or merozygote. All the recombinants tested were colicinogenic, nearly all producing colicines *I* and *E*1 in crosses where both factors were present in the donor mixture, whereas only about 25 per cent of acceptor bacteria acquire colicinogeny during the time allowed for mating. We suppose, therefore, that a zygote (or merozygote) results from a conjugation in which colicine factors are transferred.

It is not yet completely certain that gene transfer occurs only from the colicinogenic donor to the acceptor strain, and not also the other way about. However, this is probably so since the result of a cross is affected according to which parent is colicinogenic. For example: (1) in some crosses at least, the unselected markers of the strain accepting colicinogeny are much more frequent in recombinants than are their alleles from the donor strain; (2) colicine factor *E*1 greatly increases the frequency of recombination when it is present in the donor strain, but not when it is present in the acceptor strain; and (3) exposure of the mating mixture to streptomycin for 90 min. much reduces the yield of recombinants when the acceptor strain is streptomycin-sensitive and the donor strain is streptomycin-resistant; but has little effect when the acceptor of colicinogeny is streptomycin-resistant and the donor is sensitive.

Recombination in this system may be fundamentally similar to that mediated by the *F* factor in *Escherichia coli*. The presence of colicine factor *I* in *Salmonella typhimurium*, like that of the *F* factor (in either the *F* + or the *Hfr* form) in *E. coli*, enables the bacteria to pair, although the effect of factor *I* is very small except in bacteria which have recently acquired it; in factor *I*-induced pairing, as in pairing induced by the *F* factor in its *F* + state, chromosomal recombination occurs at a very low rate. The effect of factor *E*1 in raising the rate of recombination in factor *I*-induced pairing is more obscure; one may speculate that it facilitates the opening of the (presumed) closed-loop chromosome of the donor

bacterium, so encouraging its transfer, in whole or in part, to the acceptor bacterium (compare the effect of the *F* factor in *E. coli* on passing from the *F* + to the *Hfr* state).

H. Ozeki
Sheila Howarth

Guinness-Lister Research Unit,
Lister Institute of Preventive Medicine,
Chelsea Bridge Road,
London, S.W.1.

Escherichia coli K-12

The transfer of genetic material from one strain of *Escherichia coli* K-12 to another is dependent on a fertility factor, termed *F*, which determines the donor state; two K-12 strains devoid of *F* (*F*⁻ strains) are normally non-fertile when mixed together[6,7]. The *F* factor has been classed as an *episome* by Jacob, *et al.*[8], existing in the autonomous (cytoplasmic) state in the *F*⁺ cell, and in the integrated (chromosomal) state in the *Hfr* cell. The integrated state of *F*, and of other episomes, appears to be related to the ability to promote the genetic transfer of other stably chromosomal characters. Colicinogeny (the heritable ability to produce an antibiotic-like protein called colicin) has also been shown to be determined by factors which have certain episomal characteristics[8].

Two lines of evidence have pointed to the implication of colicinogeny as a genetic vector in K-12. Furness and Rowley[9] reported that certain naturally occurring strains of *E. coli*, although showing no direct evidence of fertility with K-12 *F*⁻ strains, could, nevertheless, transfer to them a fertility factor which rendered these K-12 strains fertile with other K-12 strains. Unlike *E. coli* K-12, most of these wild-type coliform strains were found to be colicinogenic, the majority for colicin *I*, as were the infected K-12 *F*⁻ derivatives. However, colicinogeny and fertility do not appear to be determined by the same factor in these strains. This conclusion was reached after treatment with either cobalt chloride[9] or acridine orange, which have been shown to be effective in 'curing' or eliminating the *F* factor from *F*⁺ strains[10,11]. After treatment, the fertile, colicinogenic K-12 strains lose their fertility but preserve their colicinogeny.

More recently, Ozeki *et al.*[12] have demonstrated the transfer by conjugation of what appear to be large segments of chromosome from a donor strain to a recipient strain of *Salmonella typhimurium*. The donor state in this case is conferred by the *recent* transfer of colicinogeny from a third strain which is specifically colicinogenic for colicin *I*. If the donor strain is in addition colicinogenic for colicin *E*1, the frequency of transfer is increased about 100-fold, to yield one recombinant/approximately 10^8 recipient cells. These colicinogeny determinants, *I* and *E*1, can be transferred to *E. coli* K-12 by mixing a culture of this strain with a culture of *S. typhimurium* which carries them[13]. An investigation was therefore undertaken of the fertility state of *F*⁻ K-12 strains subsequent to the transfer of these particular colicinogeny determinants. Two auxotrophic *F*⁻ strains of *E. coli* K-12 were employed: 58–161 *F*⁻, which requires methionine, and W945 *F*⁻, which requires threonine, leucine and thiamine for growth. In the first experiment, the method of Ozeki *et al.* was followed closely. *S. typhimurium* carrying colicinogeny *I* (col. *I*⁺) and 58–161 *F*⁻ were grown overnight in mixed broth culture; the mixture was then diluted 1/50 in fresh broth and reincubated for 2 hr. A culture of the recipient strain W945 *F*⁻ was then added and the mixture of these three strains incubated for a further hour before washing and plating on minimal medium supplemented with thiamine. After incubation, prototrophic recombinants resulted at the low rate of about one in 10^8 W945 *F*⁻ cells plated. None of the individual strains, alone, nor in any combination of pairs, gave rise to any prototrophic colonies.

In contrast with the *S. typhimurium* system, the use of the presumptive donor strain 58–161 *F*⁻, made stably colicinogenic for *E*1, failed to increase the frequency of recombinant formation. Another point of difference is that, in *E. coli* K-12, the donor state conferred by colicinogeny *I* is stable and does not depend on recent colicinogenization. When a strain of 58–161 *F*⁻, stably colicinogenic for *I* (isolated from mixed culture with *S. typhimurium* (col. *I*⁺)), was used in a simple bi-parental cross with W945 *F*⁻, prototrophic recombinants again arose at the same low rate as before. All the recombinants tested from these experiments were colicinogenic, and fertile as donors in crosses with *F*⁻ recipients. It is, therefore, concluded that colicinogeny *I* confers on K-12 *F*⁻ strains the capacity for concomitant chromosomal and colicinogeny transfer to other *F*⁻ strains. Since *Salmonella* apparently cannot readily harbour *F*, it seems possible that in this system, as distinct from that reported by Furness and Rowley, the fertility factor is the colicinogeny determinant itself. This is supported by the fact that no recombinants arose when *Salmonella* strains, differing only in harbouring colicinogeny *E*1 or *E*2 instead of *I*, were used in experiments similar to those reported above.

A comparison was made of unselected marker transfer among a number of recombinants from a *col I*-mediated cross, and the comparable *F*-mediated cross, using 58–161 in the colicinogenic or *F*⁺ state respectively as the donor parent with W945 *F*⁻ as the recipient (Table 1). Crosses were plated on minimal medium supplemented with thiamine so that selection was made for the ability to synthesize threonine (*thr*⁺) and leucine (*leu*⁺) from 58–161, and methionine (*met*⁺) from W945. The two strains differed in seven other markers; the ability to synthesize thiamine (*thi*); to ferment the sugars arabinose (*ara*), lactose (*lac*), galactose (*gal*) and xylose (*xyl*); and resistance to the drug, sodium azide (*azi*) and the coliphage T6 (*T6*). A variety of recombinant types

Table 1. Frequency of Recombinants carrying Genetic Markers of *E. coli* Strain 58–161 when crossed with W945 *F*⁻

State of 58–161	No. of recombinants	Fraction of the recombinants carrying the 58–161 marker†								Fraction of 'double-crossover' types
		thi	*thr	ara	*leu	azi	lac	T6	gal	xyl	
(Col. *I*)-*F*⁻	55	0·04	1·0	1·0	1·0	0·90	0·37	0·24	0·11	0	0·94
(Col. *I*)⁺ *F*⁻	70	0·18	1·0	1·0	1·0	0·91	0·58	0·49	0·20	0·11	0·91

* Selected markers.
† Markers arranged in order of linkage as determined by *Hfr* and *F*⁺ crosses (ref. 14).

resulted, as indicated in Table 1. Although the *col I*-mediated cross was only one-hundredth the fertility of the *F*-mediated cross, the table shows similarities in marker transfer from both types of crosses. Assuming a one-way transfer of genetic material (the colicinogenic strain acting as a donor as in the case of the F^+ strain), and assuming the order of markers on the *K*-12 chromosome as determined by *Hfr* or F^+ crosses[14], the recombinants from both types of crosses can be accounted for by a double crossing over in more than 90 per cent of the recombinants. It appears, therefore, that the genetic fragments transferred in the *col I* cross are of the same order of size as those involved in the F^+ cross, in which, for example, the distance between *thr-gal* has been shown to be about 15 per cent of the total chromosomal length[14].

Episomal systems determining certain types of colicinogeny appear, therefore, to resemble other episomal systems such as temperate phage and more particularly *F*, in the ability to mediate genetic transfer. It is tempting to imagine that if mutation were to occur in such colicinogenic strains so as to remove the lethal effect of the colicin, it would be difficult to distinguish them readily from F^+ strains. Other possible similarities of the colicinogenic and *F* systems are being examined.

R. C. Clowes

Medical Research Council
Microbial Genetics Research Unit,
Hammersmith Hospital,
Ducane Road, London, W.12.

[1] Ozeki, H., Ph.D. thesis, University of London (1960). "Colicinogency in Salmonella: Genetic and other Studies".
[2] Ozeki, H., and Stocker, B. A. D., *Heredity*, **12**, 525 (1958).
[3] Stocker, B. A. D., *Tenth Symp. Soc. Gen. Microbiol.*, 1 (1960).
[4] Furness, G., and Rowley, D., *J. Gen. Microbiol.*, **17**, 550 (1957).
[5] Zinder, N. D., *Science*, **131**, 924 (1960).
[6] Lederberg, J., Cavalli, L. L., and Lederberg, E., *Genetics*, **37**, 720 (1952).
[7] Hayes, W., *J. Gen. Microbiol.*, **8**, 72 (1953).
[8] Jacob, F., Schaeffer, P., and Wollman, E. L., *Symp. Soc. Gen. Microbiol.*, **10**, 67 (1960).
[9] Furness, G., and Rowley, D., *J. Gen. Microbiol.*, **17**, 550 (1957).
[10] Hirota, Y., *Nature*, **178**, 92 (1956).
[11] Hirota, Y., *Proc. U.S. Nat. Acad. Sci.*, **60**, 57 (1960).
[12] Ozeki, H., Howarth, S., Smith, S. M., and Stocker, B. A. D., *Heredity* (in the press).
[13] Fredericq, P., *Ann. Rev. Microbiol.*, **11**, 7 (1957).
[14] Jacob, F., and Wollman, E. L., *Symp. Soc. Exp. Biol.*, **12**, 75 (1958).

ANALYSIS OF IRRADIATED *DROSOPHILA* POPULATIONS FOR MEIOTIC DRIVE

By Prof. E. NOVITSKI* and G. D. HANKS*

Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee†

THE existence of chromosomes or alleles that are represented in the gametes of a heterozygote with a frequency greater than the expected 50 per cent is now well established for a variety of species. The immediate population result of introducing such a chromosome or allele must be a sharp increase in its frequency, along with any other genes associated by linkage, independent of or, indeed, in spite of, their phenotypic effects[1,2]. For this reason such phenomena have been referred to as cases of 'drive' and, more specifically, as 'meiotic drive' when the basis is found in some aberration of meiosis[3]. Such instances would seem to provide an unparalleled opportunity for the study of population dynamics, for example, the efficacy of response of natural selection to unfavourable genes. It seemed worth while, therefore, to determine whether such chromosomes or alleles characterized by drive might be induced in the laboratory.

We expected that such an event would occur with a very low frequency, and would probably not be detectable in an X-ray experiment conventionally designed. Instead, chromosomes were tested that had received light doses of radiation each generation for about 200 generations. These chromosomes had been derived from the population cages kept at the Long Island Biological Laboratory at Cold Spring Harbor by Dr. Bruce Wallace, to whom we are indebted for making samples of these populations available to us.

The genetic tests consisted simply of back-crossing heterozygotes for chromosomes derived from the irradiated populations and for stock chromosomes carrying mutant genes to the mutant stock in order to detect any deviation in the progeny from the expected 50 per cent of each type. Seven different populations were tested, and the standard mutants chosen marked the distal ends and centromere regions of the three major chromosomes. Furthermore, since it could not be anticipated in which sex any disturbances of segregation might be effective, both male and female heterozygotes were tested. Of 1,654 tests there were two instances in which the chromosomes derived from the irradiated population were recovered in significantly more than half the progeny, and where this deviation persisted after repeated testing.

One of these cases involved an irradiated second chromosome, which appeared in the F_1 of male heterozygotes, with frequencies ranging from 53 to 80 per cent (Table 1). The second chromosome showed this peculiarity over six consecutive generations and in combination with a variety of different

Table 1. Chromosomes recovered from Males Heterozygous for the Irradiated Second Chromosome and Various Normal Second Chromosomes compared with a Control

Irradiated	Normal	Per cent
192	135	58·7
1,148	866	57·0
421	104	80·2
2,210	1,394	61·3
2,554	2,078	55·1
5,457	4,755	53·4
3,218	2,421	57·1
4,703	3,458	57·6
3,026	1,370	68·8
1,907	448	81·0
1,048	664	61·2
Controls:		
1,327	1,354	49·5
960	895	51·7

* Present address: Department of Biology, University of Oregon, Eugene, Oregon.

† Operated by Union Carbide Corporation for the U.S. Atomic Energy Commission.

stock second chromosomes. The bottle stock carrying this chromosome was left unattended for a period of several months, and subsequent re-testing failed to uncover it again. In the meantime the population from which this was originally derived was unfortunately discarded. It is not clear why we should not have been able to recover it again in the unselected population if it were in fact a bona fide case of drive.

In the second case, an irradiated *X* chromosome when present in a parental male, appears in 56–64 per cent of his progeny (Table 2). This has persisted over 20 consecutive generations; in fact, the mean recovery is now 67 per cent, presumably because of the persistent selection exercised in each generation for genes which accentuate the discrepancy. As in the preceding case, this chromosome behaves normally in the heterozygous female.

Table 2. Numbers of *X* and *Y* Chromosomes Recovered, in Female and Male Progeny, respectively, from Males Carrying the Irradiated *X*, with a Control Set for Comparison

Male	Female	Per cent female
1,267	1,675	56·9
962	1,327	58·0
797	1,192	60·0
491	799	61·9
329	535	61·9
656	973	59·7
655	858	56·1
428	762	64·0
234	409	63·6
Controls:		
973	1,077	52·5
520	524	50·2

Evidence that inequality of recovery of the two homologues (in this case the *X* and *Y* chromosomes) is not simply differential mortality of the male progeny caused by this particular *X* chromosome may be found in the following observations:

(1) When matings are made to attached-*X* females instead of ordinary females with free-*X* chromosomes, the deviation persists but with reversed direction, as one might expect if more eggs were being fertilized by *X*- than by *Y*-bearing sperm.

(2) Pair matings were made of females with males which carried the irradiated *X* chromosome. After eggs were collected and carefully counted, the sex of the adults emerging was scored. The overall mortality was simply the difference between the eggs laid and the total emerging adults. A χ-square test was made of the deviation in sex ratio, but to ensure the most conservative test, the overall mortality was added to the least frequent class, the male class. Even with this correction, which would tend to minimize the magnitude of the difference between the two classes, the *P* value was less than 0·005. This refutes the possibility that the difference between the numbers of the two sexes recovered may be explained by mortality and supports the alternative that it is caused by some pre-zygotic mechanism, as meiotic drive.

(3) At lower temperatures (18° C.) the magnitude of the effect is depressed, 56 per cent recovery, as opposed to 67 per cent at 25° C. However, if a male develops at 18° C. and is then mated in a culture bottle at 25°, which is then kept at the higher temperature during the development of the progeny, the resulting ratio in the progeny is that characteristic of the low temperature, not the higher, as would be expected if zygote mortality were responsible.

Those three lines of evidence speak strongly for an action before fertilization and possibly during meiosis, which would qualify this case for inclusion under the heading of meiotic drive. Preliminary cytological examination has revealed nothing unusual, but unless the basis for this effect were something quite obvious (as, for example, the formation of anaphase bridges as in 'segregation-distorter'[4]), one would not hope to have much success in this effort with a species the meiosis of which is as intractable cytologically as is that of *Drosophila melanogaster*.

We wish to acknowledge the contribution of technical assistance of Mrs. R. D. Wilkerson, the innumerable helpful suggestions of the genetics group at the Oak Ridge National Laboratory, and the invaluable assistance of Dr. Allyn Kimball, who constructed criteria based on sequential analysis, which expedited the testing enormously.

[1] Dunn, L. C., *Acta Genet.* (Basel), **4**, 139 (1953).
[2] Prout, T., *Acta Genet.* (Basel), **4**, 148 (1953).
[3] Sandler, L., and Novitski, E., *Amer. Nat.*, **91**, 105 (1957).
[4] Sandler, L., Hiraizumi, Y., and Sandler, I., *Genetics*, **44**, 233 (1959).

CHROMOSOME FRAGMENTS AND MUTATION OF THE INCOMPATIBILITY GENE

By Prof. D. LEWIS, F.R.S.
Department of Botany, University College, London

In a study in *Petunia inflata* of changes in the self-incompatibility system, Brewbaker and Natarajan[1] found self-compatible plants among the selfed generation after X-radiation of the pollen mother cells. This is similar to results obtained in *Oenothera organensis*, *Prunus avium*[2] and *Trifolium* species[3], which have been interpreted on a basis of mutation of the self-incompatibility *S* gene. Brewbaker and Natarajan discovered, however, that their self-fertile plants had a small centric chromosome fragment extra to the normal diploid set of chromosomes. Their analysis supports very fully their interpretation that the fragment carries the *S* gene, and that a self-compatible plant has two alleles, say S_1 and S_2, in the normal pair of chromosomes, and either S_1 or S_2 in the fragment. Such a plant will produce 50 per cent pollen grains with one normal *S* chromosome, and the fragment. Half these fragment-carrying pollen grains have a different *S* allele in normal and fragment chromosomes.

It has long been known that a diploid pollen grain with two different, but not two like, *S* alleles has a weakened incompatibility reaction or has lost it altogether. This effect has been called competitive interaction between the *S* alleles so that neither allele produces its specific protein, which is responsible for the incompatibility reaction[4]. When the incompatibility reaction has been completely lost by competitive interaction, a plant with diploid pollen grains is fully self-compatible. When the incompati-

Intermediary Metabolism in Plants

D. D. DAVIES

A review of the ideas and theories of biochemical action in plants with a discussion of how the theories developed by animal biochemists need to be modified when applied to plant metabolism. The book is based on a course of lectures given to honours students of botany at London University. *Cambridge Monographs in Experimental Biology.* 20*s. net*

Microbial Reaction to Environment

EDITED BY G. G. MEYNELL & H. GOODER

The contributors to the eleventh *Symposium* of the Society for General Microbiology discuss changes in the morphology metabolism and behaviour of a wide range of micro-organisms brought about by changes in their environment, with particular reference to non-genetic variations. 8 *plates;* 55 *text-figures;* 20 *tables.* 42*s. net*

CAMBRIDGE UNIVERSITY PRESS

BACK ISSUES OF JOURNALS IN SCIENCE & THE HUMANITIES

ALWAYS REQUIRED BY:
WM. DAWSON & SONS, LTD.,
BACK ISSUES DEPT.,
16 WEST STREET,
FARNHAM, SURREY, ENGLAND.
TEL: FARNHAM 4664 CABLES: DAWBOOKS, FARNHAM

THE MUSEUM BOOK STORE, LTD.
25 Devonshire St., London, W.1
(Welbeck 1340)
Buy and sell Scientific Journals and Periodicals and Learned Society Publications in all languages. Librarians, and others, should send us their list of "wants", or duplicates for sale. *Binding undertaken.*

WHELDON & WESLEY, LTD.
Specialists for 100 years in
BIOLOGICAL & GEOLOGICAL BOOKS
Catalogues on Request
•
LYTTON LODGE, CODICOTE, Near Hitchin, Herts
Books Bought

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY LIBRARY

One of the privileges of Membership of the Institute of Physics and the Physical Society is the use of its Library, at the offices in South Kensington.

The Library consists of a reading room, and a larger room. A large number of runs of periodicals, both British and foreign, is held, including some of the lesser known journals as well as the standard ones. Journals are for reference only, so that a complete run can always be found on the shelves.

There is also a book section, from which books can be borrowed by Members, either on personal application or by post, and by non-Members on recommendation.

The Library is open from 9.30 a.m. to 5.0 p.m., Monday to Friday.

1 Lowther Gardens,
Prince Consort Road, S.W.7.
(Junction with Exhibition Road.)

Back Numbers of Periodicals Required

AMERICAN MINERALOGIST
Vol. 1, No. 1 ; Vol. 2, Nos. 2, 7 ; Vol. 5, Nos. 6–8 ; Vol. 9, No. 3 ; Vol. 26, complete ; Vol. 27, Nos. 1, 3–7, 10 ; Vol. 28, No. 1.

ANNALES SCIENTIFIQUES DE L'ECOLE NORMALE SUPERIEURE (PARIS)
1949 complete.

CANCER RESEARCH
Vol. 8 complete ; Vol. 11, No. 1.

CHEMICAL ABSTRACTS
Vols. 1–9 complete ; Vol. 29, Nos. 5, 6, 7, 11, 13–16, 20, 22.

GAZZETTA CHIMICA ITALIANA
Vol. 86 complete.

MINE AND QUARRY ENGINEERING
Vols. 16–22 complete.

NATURE
Vols. 146–154.

OIL AND GAS JOURNAL
Vols. 26–27 complete ; Vol. 52, Nos. 35, 40 ; Vol. 53, Nos. 34, 39, 48.

PETROLEUM PROCESSING
Vol. 1 complete.

PLANT PHYSIOLOGY
Vol. 5 complete ; Vol. 15, No. 4.

ROYAL SOCIETY PROCEEDINGS, LONDON
Vols. 1–3, 7, 9, 10, 15, 31, 51, 90–106.

GERMAN LIFE AND LETTERS
Vols. 1–12 complete.

YOUR HOLDINGS OF DUPLICATES OR JOURNALS NO LONGER WANTED

We will gladly pay highest market prices for your duplicates, and if needed will send one of our own librarians to collate, pack and despatch them. Should you have any journals for disposal please telephone or write—

I. R. MAXWELL and Co. Ltd.
Headington Hill Hall, Oxford
Tel. 64881. Cables : LEXICOM. Telex 83177.
Offices also at :
103, Fifth Avenue, New York 3, Tel. Chelsea 2-2100.
Kaiserstrasse 75, Frankfurt am Main. Tel. 33.74.61.
24 rue des Ecoles, Paris Ve. Tel. ODEon 30-00.

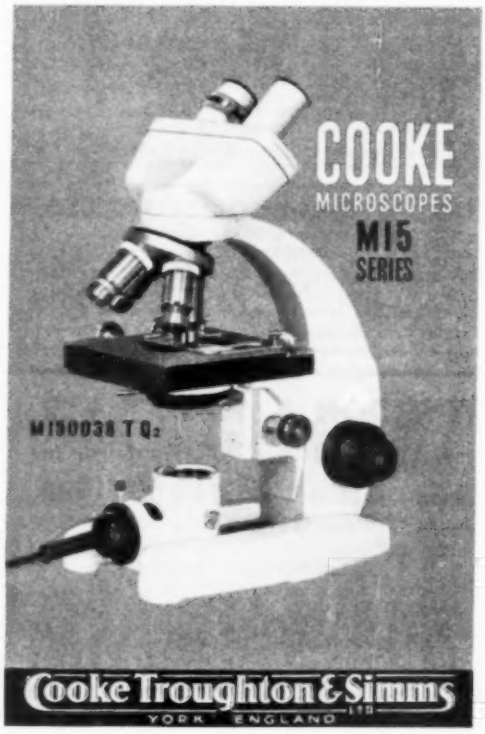
GLASS

All Glass Requirements for Scientific Instrument Manufacturers and Research Workers

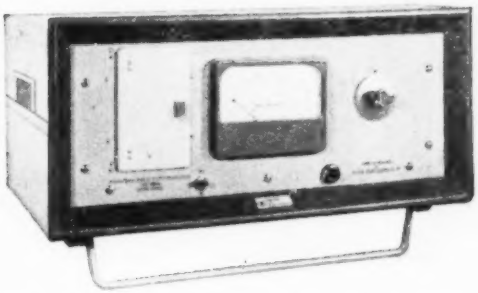
- SHEET & PLATE-GLASS—cut and ground to exact dimensions.
- LENSES, PRISMS & FLATS—to any standard of accuracy.
- MIRRORS—back silvered and front surface aluminised, etc.
- BLOOMING of optical components.

C. J. WHILEMS, LTD.
ILFORD OPTICAL WORKS
FOREST ROAD, BARKINGSIDE, ESSEX

Telephone : HAInault 5454-5



EKCO Vibrating Reed Electrometer



The Vibrating Reed Electrometer Type N616 measures very small direct currents and voltages with high zero stability.

Applied D.C. is converted to A.C. by means of a vibrating reed capacitor and amplified by a stable A.C. amplifier.

The output is rectified and measured on a 5" (13 cm) panel meter calibrated to indicate the D.C. voltage at the input.

An ionisation chamber may be mounted directly on the Electrometer unit in place of the Input connector which may be detached.

RANGES

Seven ranges are provided :—

1. 3 mV 2. 10 mV 3. 30 mV 4. 100 mV
5. 300 mV 6. 1 V 7. 3 V

INPUT RESISTANCE

Three switched input resistors are provided :—

1. 10^8 ohms 2. 10^{10} ohms 3. 10^{12} ohms

ACCURACY

Accuracy is of the order of $\pm 1\%$ for voltage measurements. Current measurements are controlled by the value of the input resistors. These are a $\pm 5\%$ matched triple.

STABILITY

Long-term stability better than $\pm 100\mu V$ at constant temperature. Short-term stability $\pm 10\mu V$.

MAINS INPUT

110-120 V and 200-250 V, 50-60 c/s. Power consumption 60 watts.

CALIBRATION

A jack is provided which enables the instrument to be calibrated against a standard reference potential.

OUTPUTS

A 100 mV recorder can be operated. 215 volts at 5 mA, —105 volts at 2 mA and 6.3 volts at 0.3 A are provided for external equipment.

DIMENSIONS

Electrometer unit 6" x 7¼" x 9½" (15 x 18.5 x 24 cm).
Indicator unit 19" x 8¾" x 13" (48 x 22 x 33 cm).

WEIGHTS

Complete with cables 30 lb. (13.6 Kg).

EKCO ELECTRONICS LIMITED

Sales, Installation and Service

SOUTHEND-ON-SEA · ESSEX · Telephone: Southend 49491

WPS 307

ACADEMIC

Mathematics in Science and Engineering

A Series of Monographs and Textbooks

Edited by RICHARD BELLMAN, *The RAND Corporation, Santa Monica, California*

Volume 2

Plastic Flow and Fracture in Solids

By TRACY Y. THOMAS, *Graduate Institute for Mathematics and Mechanics, Indiana University, and United States Naval Research Laboratory*

June 1961, 267 pp., 68*s*.

This book is devoted to a study of the propagation, growth, and decay of discontinuities in solids, including the theory of characteristic surfaces and the spread of plastic into elastic regions. The material is based largely on articles published by the author in various mathematical journals during the preceding five years. Engineers and students of the theory of plasticity will find this volume of genuine interest and of aid in the solution of some of their problems.

Basic Invariants in the Mechanics of Continuous Media. Equations of Continuity and Motion
Conditions of Compatibility
Waves in Elastic Media
Perfectly Plastic Solids. Appendix: Equilibrium Theory of Luders Bands
Characteristic Surfaces and Wave Propagation
Instability and Fracture
SUBJECT INDEX.

Volume 3

The Optimal Design of Chemical Reactors

A Study in Dynamic Programming

By RUTHERFORD ARIS, *Institute of Technology, University of Minnesota*

July 1961, 191 *pp*.

Introduction
The Principal Notions of Dynamic Programming
Mathematical Models for Reactor Design
The Objective Function
The Continuous Flow Stirred Tank Reactor
The Multibed Adiabatic Reactor
The Tubular Reactor
Stochastic Problems
The Optimal Operation of Existing Reactors
References
INDEX.

Previously Published:

Volume 1

Concepts from Tensor Analysis and Differential Geometry

By TRACY Y. THOMAS — *February* 1961, 119 *pp*., 40*s*.

In Preparation:

Stability by Liapunov's Direct Method with Applications

By JOSEPH LASALLE *and* SOLOMON LEFSCHETZ

Differential-Difference Equations

By RICHARD BELLMAN *and* KENNETH L. COOKE

NEW YORK 111 Fifth Avenue, New York 3

PRESS NEW YORK and LONDON

Pure and Applied Physics

A Series of Monographs and Textbooks

Consulting Editor : SIR H. S. W. MASSEY, *University College, London*

Volume 11

The Quantum Mechanics of Many-Body Systems

By D. J. THOULESS, *Birmingham University*

June 1961, 175 *pp.*, 44*s.*

This book is a unified introduction to many-body theory. It is concerned with problems common to nuclear physics, atomic physics, the electron theory of metals, and the theory of liquid helium three and four ; and it describes the methods which have recently been developed to solve such problems. Main emphasis is on the theories of atomic nuclei, electron gas, and liquid helium.

Soluble Models
Variational Methods
Perturbation Theory
Low-Lying Excited States
Statistical Mechanics and Superconductivity Theory
Perturbation Theory at Finite Temperatures
Green's Functions at Finite Temperatures
Bosons
References
SUBJECT INDEX.

Recent Volumes :

Volume 8

Wave Propagation and Group Velocity

By LÉON BRILLOUIN

1960, 154 *pp.*, 48*s.*

Volume 9

Nuclear Spectroscopy

Complete in 2 parts

Edited by FAY AJZENBERG-SELOVE

PART A: 1960, 621 *pp.*, 114*s.* 6*d.*

PART B: 1960, 523 *pp.*, 114*s.* 6*d.*

Volume 10

Quantum Theory

Complete in 3 parts

Edited by D. R. BATES

Part I, ELEMENTS

June, 1961, 447 *pp.*, 80*s.*

Part II, AGGREGATES

1961, *in preparation*

Part III, RADIATION AND HIGH ENERGY PHYSICS

1961, *in preparation*

In Preparation :

An Introduction to Elementary Particles

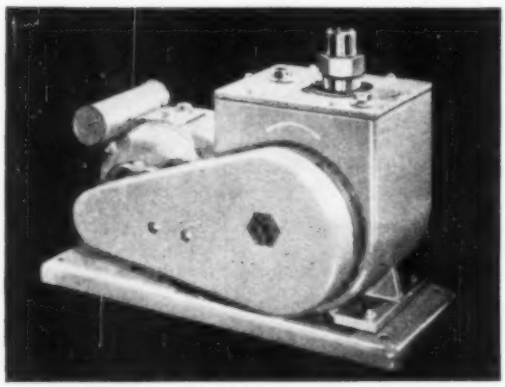
By W. S. C. WILLIAMS

Phone : WHItehall 6631

17 Old Queen Street, London, S.W.1 LONDON

OPERATION

High vacuum components

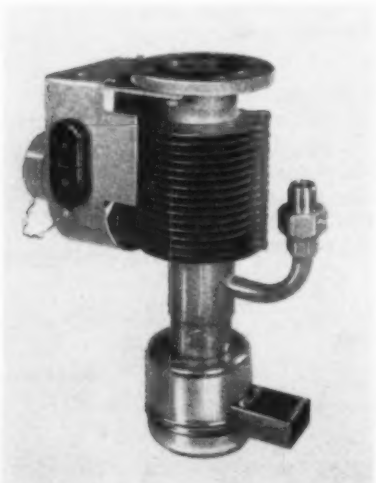


ROTARY VACUUM PUMPS
S.24 Rotary Vacuum Pump. Speed 2.1 litres sec at 1.0 mm Hg.

High vacuum problems? Talk to AEI. The range of METROVAC components, already proved in AEI systems, will help you build *your* vacuum systems. The AEI service is also complete.

METROVAC specialists can give you advice of a general or specific kind on the installation and assembly of components to achieve the result you need. Here are a few examples of METROVAC components:

VACUUM GAUGES
Type VG 14. Barometrically-compensated Absolute Pressure Gauge.



DIFFUSION PUMPS
A.022A Type. Speed up to 40 litres/sec below 10^{-3} torr.

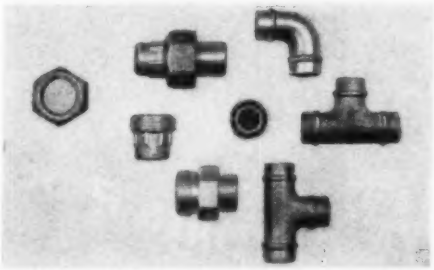
AEI

METROVAC

– a complete service

VACUUM PLUMBING

A comprehensive range of unions for use with BS 659 standard light gauge copper tube in gauges $\frac{1}{4}$" to $1\frac{1}{2}$" bore.



'PHONE OR WRITE TO YOUR AEI OFFICE

Talk to AEI about vacuum problems. Contact the nearest AEI office from the list below, asking for the METROVAC engineer. Or write direct to the AEI Instrumentation Division.

Belfast
19 Ormeau Avenue
Tel: Belfast 32977

Birmingham
65 Smallbrook, Ringway, 5
Tel: Midland 6335 and 9551

Bristol
5 Queen Square, 1
Tel: Bristol 292911

Cambridge
133 Fitzroy Street
Tel: Cambridge 54370

Cardiff
Mervyn House, Frederick Street
Tel: Cardiff 28511/4

Edinburgh
61a Queen Street, 2
Tel: Caledonian 1158/9

Glasgow
74 Waterloo Street, C.2
Tel: Glasgow City 2939

Hull
Seaton Buildings, Jameson St.
Tel: Hull 26832

Ipswich
28 Crown Street
Tel: Ipswich 53941

Leeds
St. Paul's House, St. Paul's St., 1
Tel: Leeds 20718 and 20444 5

Leicester
81 Charles Street
Tel: Leicester 27909

Liverpool
18 Hepworth Chambers,
Church Street, 1
Tel: Royal 4391

London
33 Grosvenor Place, S.W.1.
Tel: Belgravia 1234

Manchester
15 Quay Street, 3
Tel: Blackfriars 2691
and Ship Canal House, King St., 2
Tel: Deansgate 5031

Middlesbrough
59 61 Albert Road
Tel: Middlesbrough 2476

Newcastle
24 Northumberland Road,
Newcastle upon Tyne, 1
Tel: Newcastle 26060

Nottingham
24 Stoney Street
Tel: Nottingham 51431

Preston
14 Winckley Square, Lancs.
Tel: Preston 4253

Sheffield
9 Market Place, 1
Tel: Sheffield 23114 and 27848

Stoke
Stoke Rd., Stoke-on-Trent, Staffs
Tel: Stoke-on-Trent 48639

Swansea
166 St. Helens Road, Glam.
Tel: Swansea 56968 and 56950

Wolverhampton
27 Darlington Street
Tel: Wolverhampton 25606

Workington
Westminster Bank Chambers,
Oxford St. Tel: Workington 795

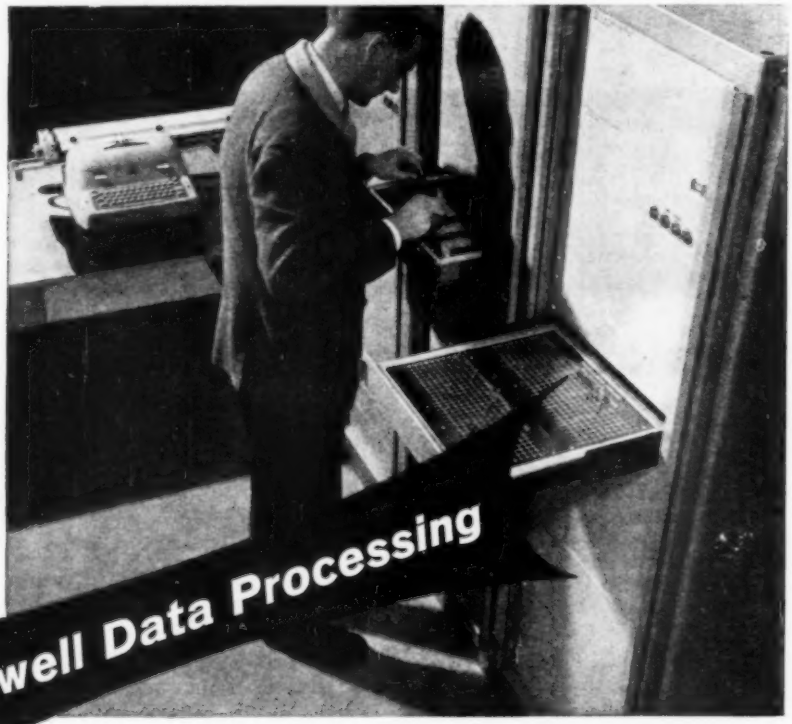
Mention the key word 'Metrovac' in your inquiries.

Associated Electrical Industries Limited

Scientific Apparatus Department **Instrumentation Division**

TRAFFORD PARK, MANCHESTER 17

N.P. 101



Honeywell Data Processing

for Industry and Research

Logging equipment, incorporating 'Pinboard Programming' at R.A.E. Farnborough

At the Royal Aircraft Establishment, Farnborough, a Honeywell three-bay data processing system with electric typewriter print-out is now logging:

139 temperature inputs in 3 ranges
0 to 99·9°C, 0 to 650°C, −50 to 300°C

96 pressure inputs in 4 ranges
0 to 20 p.s.i., 0 to 50 p.s.i., 0 to 200 p.s.i.,
0 to 500 p.s.i.

4 speed measurements
1 reference point

The equipment is based on the Honeywell Digital Potentiometer principle. It makes extensive use of mercury wetted relays and incorporates a unique feature—Pinboard Programming. Drawer-mounted pinboards add an easy flexibility to adjustments of span, zero suppression and alarm limit settings. Only a simple repositioning of pins is required to change these functions. Speed of operation, simple maintenance and continuous checks are other built-in advantages of this Honeywell system. It is suitable for research, industrial development and may also be used to supply information to computers. Annunciator panels, linearisation circuits and other features are available.

WRITE OR SEND THE COUPON TODAY to
Honeywell Controls Limited, Greenford, Middlesex. Waxlow 2333.

I am interested in Honeywell data processing (logging/scanning) equipment

for .....

Please send me Specification Sheets SS 306-1, SS 312-1

Name .....

Position .....

Company .....

Address .....

N

Sales Offices in the principal towns and cities in the United Kingdom and throughout the world.

Honeywell

First in Control

SINCE 1885

IF *you are a user of apparatus, materials and other products intended specifically for use in laboratories*

You cannot afford to miss

THE LABORATORY APPARATUS AND MATERIALS EXHIBITION

Whatever field your laboratory work covers you will find the largest ever display of new and established products to meet your every requirement at the Laboratory Apparatus and Materials Exhibition where more than sixty leading British and Overseas Manufacturers and Suppliers will be displaying specialized equipment and materials.

Twelve Scientific lectures will be delivered by eminent authorities in the various sciences, in the lecture theatre during the Exhibition.

JUNE 19-20-21-22, 1961

ROYAL HORTICULTURAL SOCIETY'S NEW HALL, WESTMINSTER, S.W.1.

10 a.m. — 6 p.m. Monday & Tuesday
10 a.m. — 8 p.m. Wednesday
10 a.m. — 4 p.m. Thursday

The ONLY one of its kind to be organised in the U.K. on a National Scale.

LABORATORY APPARATUS & MATERIALS EXHIBITION

Free Admission Ticket

ADMISSION TICKET

Complete the coupon with your name and firm's name and address, and cut round the dotted line.
Presentation of this completed coupon will entitle the bearer to free admission to the Exhibition.

Name .....

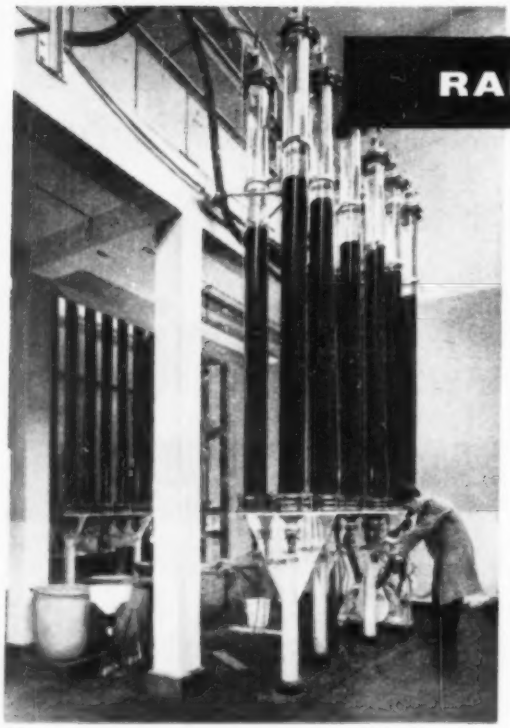
Firm's Name.....

Firm's Address.....

LABORATORY APPARATUS & MATERIALS EXHIBITION

Sponsored by "Laboratory Practice" & organised by U.T.P. Exhibitions Ltd.

9, GOUGH SQUARE, FLEET STREET, LONDON, E.C.4. Tel.: FLEet 3172



RARE EARTHS

Research into the application of ion-exchange techniques to the separation of rare earths has made available these materials in quantity and in several grades of purity.

Improved methods for the production of the rare earth metals have also been successfully developed, and all of the fourteen naturally-occurring elements, together with the related elements scandium and yttrium, are now supplied in a variety of forms. Impurities are held at a very low level, and in some cases the purity of these metals is higher than has hitherto been achieved.

- *SCANDIUM*
- *YTTRIUM*
- *LANTHANUM*
- *CERIUM*
- *PRASEODYMIUM*
- *NEODYMIUM*
- *SAMARIUM*
- *EUROPIUM*
- *GADOLINIUM*
- *TERBIUM*
- *DYSPROSIUM*
- *HOLMIUM*
- *ERBIUM*
- *THULIUM*
- *YTTERBIUM*
- *LUTETIUM*

Details of purity and availability of the rare earths will be forwarded on request. Salts of any of the elements can be prepared to meet individual demands, and all the rare earth metals can now be produced.

Specialised Products of

Johnson Matthey

JOHNSON, MATTHEY & CO., LIMITED
73-83 HATTON GARDEN, LONDON, E.C.1 Tel.: Holborn 6989
Vittoria Street, Birmingham, 1. Telephone: Central 8004
75-79, Eyre Street, Sheffield, 1. Telephone: 29212

RE 01

Lock PORTABLE

CONDUCTIVITY BRIDGE TYPE BC 1

This mains-operated instrument has a bridge frequency of 1500 c/s, and covers the very wide range of 0·05 to 1×10^6 micro mhos in seven ranges.
A portable fully-transistorised bridge is also available. It covers the range of 0·5 to 1×10^6 micro mhos in six ranges.

Lock NUCLEAR CHEMICAL ELECTRONIC INSTRUMENTATION

A. M. LOCK & CO. LTD.
Prudential Buildings, 79 Union Street, Oldham, Lancs
Telephone: MAin 6744

C.W. 7751

'AMBERLITE' Ion Exchange Papers

These papers, combining the functions of ion exchange with those of paper chromatography, offer a new and convenient analytical technique to the laboratory.

They are prepared from a mixture of finely-divided ion exchange resin and pure -cellulose pulp, made into paper by conventional methods and contain about 45% of resin by weight; the resulting high density of ion exchange units is obtained without sacrificing wet or dry strength, and in practice leads not only to separation but to concentration of the components in a test mixture. The resins used are stable in the pH range 1-14; all ionic forms of the resins are insoluble in aqueous solutions and in organic solvents.

In chromatographic work these papers show several advantages over an ion exchange column, among them smaller samples, shorter time, and no fraction collecting, and often the fractions may be stained direct.

The four grades of 'Amberlite' Ion Exchange Papers cover a wide range of uses:

Ion Exchange Paper	Functional Groups	Ionic Form as Supplied	Examples of Separations Performed
'Amberlite' SA-2	Sulphonic acid	Na^+	Amino acids; aromatic amines
'Amberlite' WA-2	Carboxylic acid	H^+	Copper, cobalt, nickel; vitamins
'Amberlite' SB-2	Quaternary ammonium	Cl^-	Iodide, iodate, periodate; carbohydrates
'Amberlite' WB-2	Primary and Secondary amine	OH^- (free base)	Fatty acids; haemoglobin

Used as filter media the papers should remove traces of ionisable impurities from solution, and clarify the solution at the same time. Further information on their properties and uses is contained in the B.D.H. leaflet "Amberlite' Ion Exchange Papers" which is available free on request.

BDH

THE BRITISH DRUG HOUSES LTD.
B.D.H. Laboratory Chemicals Division · Poole · Dorset

GRAFLEX

The world's finest industrial cameras

CROWN GRAPHIC SPECIAL 45

The basic Graphic Camera for press and technical work. Built-in coupled rangefinder, parallax corrected optical viewfinder, rangelite for focusing in the dark and open frame finder. Double extension, rising, tilting and shifting front and Graflok back with Ektalite field lens.

CF.904. With 135 mm. f/4.7 Xenar in No. 0 Compur shutter.

CROWN GRAPHIC FLASH SPECIAL 45

C.F.905. As above, but including Graflite Junior flash-gun and connecting cord.

also **SUPER SPEED GRAPHIC**
PACEMAKER CROWN GRAPHIC
GRAPHIC VIEW

Manufactured by Graflex Inc., Rochester, U.S.A.

For further details and price list write to Sole Wholesale Distributors:

NEVILLE BROWN & CO. LTD. · 93-97 NEW CAVENDISH STREET · LONDON W1

The place of the Particle Accelerator in Basic Research

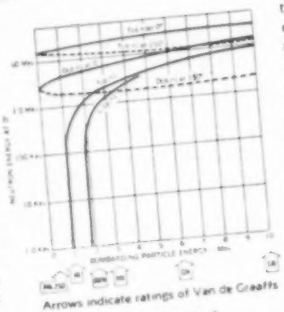
Monoenergetic Neutrons—VII

Since their discovery in 1932, neutrons have been widely used in nuclear bombardment studies. Investigations of excited levels of compound nuclei produced by inelastic collisions with neutrons have enabled physicists to develop models describing these interactions.

Accelerators Gave Control

The early work with neutrons was carried out with radioactive sources. The need for control and precision soon led to the use of particle accelerators as sources of monoenergetic neutrons. Studies were confined to the Mev range from exoergic reactions such as H^2 (d, n) He^3 and H^3 (d, n) He^4. Moderation of these fast neutrons was possible, but monoenergetic sources of slow neutrons could not be provided until the development of the atomic reactor in 1942. The subsequent use of monochromators made homogeneous beams of slow neutrons available.

Much work has been carried out with these thermal-neutron beams in measuring energy levels and spacings but, because of the dimensions of the crystal lattice, the maximum energy is confined to the order of tens of electron volts. The development of mechanical choppers has extended the energy range of monoergic neutrons to the low kev region, but even this method fails above about 20 kev.



Arrows indicate ratings of Van de Graaffs

Fast Neutrons Needed

The only useful source of monoenergetic neutrons in the high kev range is provided by endoergic reactions of accelerated charged particles with suitable target nuclei. These reactions have threshold energies of the order of a few Mev. At this energy, the neutrons are emitted with the velocity of the compound neucleus. By varying the energy of the incident beam and the angle of observation, any neutron energy from about 30 kev to several Mev can be obtained. An excellent description of the angular-energy relationship has been given by Hansen, Taschek and Williams[1].

The most suitable reactions for monoenergetic-neutron production are H^3 (p, n) He^3 and Li^7 (p, n) Be^7. The former has a threshold of 1.019 Mev and the latter, 1.88 Mev. While the tritium reaction has a broader energy range than the Li^7 reaction, it is difficult to use. The gas must be adsorbed on a suitable metal and care taken to keep the temperature below 100°C. Gas targets have been used but require a thin window between the vacuum system and the gas chamber, producing energy spread in the proton beam. Lithium is a more suitable target material, but above neutron energies of about 600 kev a second neutron group appears.

Variable Monoenergetic Beam Needed

The range of energies available depends on the energy of the incident proton beam, as shown above. The accelerator must have a continuously variable energy if a wide variation of neutron energy is to be obtained.

Neutron energy homogeneity is limited by target thickness, scattering material near the neutron target, and finally, the energy homogeneity of the proton beam. The former are experimental variables. The latter is an inherent property of the accelerator. Monoenergetic beams from the Van de Graaff® have long been considered to be the most suitable for this type of work, and leading nuclear physics laboratories throughout the world are now using Van de Graaffs built by High Voltage Engineering Corporation.

Write for a copy of our new particle-accelerator bulletin.

References.
1. A. O. Hansen, R. F. Taschek, J. H. Williams, Revs. Mod. Phys. 21, 639, 1949.

HIGH VOLTAGE SERVICING CO., LTD.
60 Carpenters Wood Dr.
Chorley Wood, Herts.

HVEC ARCO

HIGH VOLTAGE ENGINEERING
CORPORATION
BURLINGTON, MASSACHUSETTS • U.S.A.
APPLIED RADIATION CORPORATION • HIGH VOLTAGE ENGINEERING (EUROPA) N.V.

bility is only weakened, then the pollen tubes are less inhibited, but they are still unable to effect fertilization and produce seed when growing on their own style. The plant is therefore still self-incompatible.

This competitive interaction is the basis of Brewbaker and Natarajan's interpretation of the fragment and self-compatibility in *Petunia*. A plant which produces pollen grains with a normal chromosome with S_1 and a fragment with S_2 will exhibit competitive interaction between the alleles, and will be self-compatible.

The finding of a chromosome fragment and the behaviour of the self-compatible plants both as male and female parents in *Petunia inflata* proves conclusively that the change to self-compatibility induced by the X-rays and the selective method of self-pollination is due to the presence of two competing alleles in disomic pollen grain and not to mutation of the *S* gene itself. This is certainly true of the five self-compatible plants analysed. It may or may not be the explanation for the remaining 16 self-fertile plants which have not been reported in detail.

The extra *S* fragment in these self-compatible plants is precisely what would have been expected on the hypothesis of competitive interaction in a genus such as *Petunia*, where competitive interaction results in a complete loss of the pollen incompatibility reaction. This was shown by the data of Stout and Chandler[5] and interpreted by Lewis[4].

Brewbaker and Natarajan claim that a chromosome fragment and competitive interaction can explain results obtained by me in mutation studies in *Oenothera organensis*.

I propose to dispose of the *S* fragment explanation of self-compatible plants in *Oenothera* only. The arguments and findings given apply also to many of the self-compatible plants in *Prunus* and *Trifolium*, but these will not be discussed.

First, the competitive interaction in diploid pollen grains with two different *S* alleles in *Oenothera* has been analysed in detail in the combinations between *S* alleles used in the mutation studies. None of the pairs of different alleles showed competition strong enough to result in self-compatibility. Longer pollen tubes on selfing tetraploids were produced, but there were no seeds except in a tetraallelic plant $S_{2\text{-}3\text{-}4\text{-}6}$ which gave only eleven seeds from 15 flowers pollinated, which is less than 1 per cent of the compatible seed set. The plants are therefore not self-compatible[4].

In *Oenothera organensis* the progeny obtained after X-ray treatment and self-pollination contained two classes: 50 per cent of heterozygotes S_1S_2' and 50 per cent of 'homozygotes' S_2S_2', where S_2' is a mutated form of S_2. This S_2' mutant confers full self-compatibility on the plant. These two genotypes can be unambiguously identified by their reaction as female parent in test crosses. The S_1S_2' plants as female inhibit both S_1 and S_2 pollen. S_2S_2' plants inhibit only S_2 pollen. Homozygotes of the type $S_2'S_2'$ were found in the progeny from selfing the S_2S_2' plants.

In *Petunia*, on the other hand, all the progeny from X-ray treatment and self-pollination were identical, and reacted in the same way as the parent, that is, as S_1S_2 when used as females in test crosses. Furthermore, the progeny from selfing again the self-fertile plants contained only the one class.

In *Oenothera*, even if competitive interaction were strong enough to have resulted in self-compatibility, the presence of homozygotes of the types S_2S_2' and $S_2'S_2'$ in their expected proportions on a stable gene mutation hypothesis excludes the possibility of an *S* fragment and competition as a basis for the self-compatibility. Such homozygous plants could not produce pollen grains with two different alleles as required by the fragment explanation.

Further evidence for the mutational origin of the self-compatible plants is not necessary, but it has been found recently in the reaction of diploid pollen grains in artificially produced tetraploids[6]. Not all pairs of *S* alleles show competitive interaction; some show dominance and some show independence. In a diploid pollen grain, S_2 and S_4 are independent in their action so that both are expressed. A diploid pollen grain with a normal S_2 and a mutant S_4' is incompatible on a style with S_4' or S_4, whereas a pollen grain with S_4' alone is not incompatible on such styles. In this case the activity of S_4' in the pollen, which has been lost by mutation, has been restored by the presence of S_2', so that S_4 protein is produced. The allele S_4' has not been permanently changed by the presence of S_2, but only its activity. Such a result cannot be explained on a fragment basis.

Accepting that a class of self-compatible plants in *Petunia* after X-ray treatment is due to the presence of a fragment bearing an *S* gene, this explanation does not apply to *Oenothera organensis*, and it would be surprising if all self-compatible plants found in *Petunia* could be explained on this basis. In *Petunia*, where competitive interaction is strong enough, and the fragment is transmitted by the pollen, both *S* fragmental, *S* mutational or *S* recombinational and possibly *S* trisomic self-compatible plants should be found. In *Oenothera* only mutational or recombinational *S* plants are expected.

The sieve operating in the incompatibility system will allow different classes of mutations to pass in different species. In *Oenothera* the sieve is more discriminating than in *Petunia*. In *Petunia* a wider spectrum of mutational changes will be recovered. It is possible that, if more pollen grain were tested for mutation in *Petunia* then the S_2' type of mutant in *Oenothera* may still not be found in *Petunia*. The tests in *Petunia* were on 3,100 pollinations and this represents about 3×10^6 viable pollen grains. If the X-ray induced mutation-rate is the same in *Petunia* and *Oenothera*, only 3 self-fertile mutants of the S_2' type would be expected.

A further point of interest is that in *Petunia* self-fertile plants were not obtained after X-ray treatment and self-pollination of homozygotes of the type S_1S_1. This has led to the suggestion that the self-fertility may be due to some rare equal or unequal gene recombination[7]. In *Oenothera* this is a possible explanation in some cases but not in all, because self-fertile mutants of the S_2' type have been obtained from *S* homozygotes (Lewis and Dowrick, unpublished).

In two of the most completely analysed self-compatible mutants induced in *Oenothera* the explanation rests on the mutation of an activator part of the gene or of a separate activator gene contiguous with the *S* specificity gene[6].

[1] Brewbaker, J. L., and Natarajan, A. T., *Genetics*, **45**, 699 (1960).
[2] Lewis, D., *Adv. Genet.*, **6**, 235 (1954).
[3] Pandy, K. K., *Genetics*, **41**, 327 (1956).
[4] Lewis, D., *Heredity*, **1**, 85 (1947).
[5] Stout, A. B., and Chandler, C., *Science*, **94**, 118 (1942).
[6] Lewis, D., *Proc. Roy. Soc.*, B, **151**, 468 (1960).
[7] Brewbaker, J. L., and Shapiro, N., *Nature*, **183**, 1299 (1959).

LETTERS TO THE EDITORS

PHYSICS

A Notable Growth Spiral on Synthetic Diamond

In previous communications[1] it was reported that a few growth spirals of step height of some 100 Å. were observed on what were otherwise very smooth cubic faces of synthetic diamonds. These spirals were found only among one batch of crystals (1958) made by General Electric (U.S.A.). Of several thousand faces examined only two very clear-cut single-step spirals were found, together with another eight irregular, shallow, imperfect examples.

A stock of selected (1960) General Electric crystals was secured later, and, despite careful search, which indeed uncovered many smooth cubic faces, no spirals were detected, although a considerable number of crystals were studied.

I have been engaged for some time past in examining microcrystal diamonds recently made by de Beers of Johannesburg. These crystals are of interest in that they show numerous highly perfect faces, both octahedral and cubic. They are being examined with a high-sensitive phase-contrast microscope and with two-beam interferometry, using, for both techniques, a 4-mm. objective, with magnification × 750. The crystals are tiny, the largest being 0·1 mm. across, and on these some thousands of faces have already been examined.

Among them another single growth spiral has been found, but it is indeed striking. It appears on an irregular face, which must be an incompleted cubic face. The phase-contrast picture (× 500) is shown in Fig. 1. Although of an apparent partial triangular outline, this face is certainly not octahedral (no angles of either 60° or 120° occur between edges). It is an incompleted cubic face.

The beautifully defined spiral is clearly of cube face origin, sweeping round with marked rectangular outline. Thus once again our original finding is confirmed in that this too fits the observation that all spirals found to date on diamond appear only on

Fig. 1

Fig. 2

smooth cubic faces of synthetic diamonds and nowhere else.

This spiral is much more perfectly defined than any yet seen by us, and that it is one of considerable step height is shown by the two-beam interferogram (Fig. 2, × 500), taken with green mercury light. The height of the spiral step is about 1300 Å., which is surprisingly large.

The definition of the micrograph of Fig. 1 is so good on the original that it can be clearly seen that the spiral edge is double, and this can be detected too on the interferogram. It is worthy of note that on both the best of our earlier examples as well as on this one the complete face is covered by one single spiral.

It is once more re-emphasized that spiral growth is a quite rare phenomenon in diamond. It is certainly not the normal method of growth, either of synthetic or natural diamond, as the rarity of appearance proves.

The phase-contrast technique in use in this laboratory is capable of revealing spiral step edges as shallow as 2½ Å., and it is unlikely that any spirals have been missed on the thousands of faces studied by us.

S. Tolansky

Royal Holloway College
(University of London),
Egham, Surrey.

[1] Tolansky, S., and Sunagawa, I., *Nature*, **185**, 203 (1960); **184**, 1526 (1959).

An Upper Limit for the Resistivity of a Superconducting Film

Several experiments have been carried out to check whether the resistance of a bulk metal in the superconducting state is truly zero. The best known is that carried out by Collins[1], in which a persistent current of several hundred amperes was maintained in a lead ring for two and a half years. At the end of this time there was no measurable decrease in the

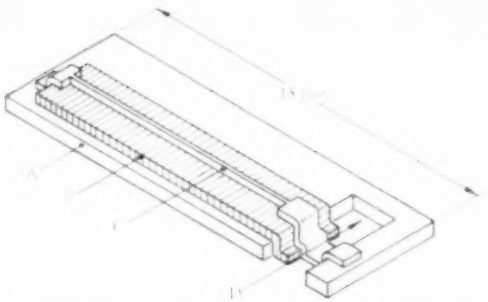


Fig. 1. Arrangement of superconducting films. Vertical dimensions not shown to scale

magnitude of the current. The resistance of the ring is quoted by Crowe[1] as less than 10^{-21} ohm, but no figure for the resistivity of the lead is given.

The question of whether the resistance of a superconducting film of thickness comparable with the depth of penetration is truly zero is of interest both from a fundamental point of view and because of the possibility of using persistent currents for storing information in computers. The present experiment was carried out to investigate this problem.

In principle, the experiment consisted of inducing a persistent current in a superconducting film, then measuring the resultant magnetic field with a bismuth Hall-effect probe of the type described by Kronick[2]. The presence of any resistance in the film would be indicated by a decay in the magnetic field. To increase the sensitivity of the measurement the L/R time-constant of the film in the normal state was made as short as possible by adopting the arrangement shown in Fig. 1. A lead film A, 1000 Å. thick, was evaporated on to a glass substrate, and a silicon monoxide insulating layer B, 2500 Å. thick, deposited on the lead in the position shown. A third film C, 800 Å. thick, composed of an alloy of lead containing 2 per cent indium, was deposited over the insulation, making contact with the lead film A at each end. The narrow section of C had a resistance of 50 ohms at a temperature just above the critical temperature ($\simeq 7^{\circ}$ K.), which is about ten times higher than if the film had been made of pure lead. However, because of the small separation between it and the 'ground plane' A, its contribution to the inductance of the loop is quite small. Measurements on a scale-model showed that the total inductance of the loop was 5×10^{-9} H., and hence the time constant $L/R_N = 10^{-10}$ sec. The bismuth Hall-effect probe was placed near the centre of the area D enclosed by the films and the arrangement immersed in liquid helium at a temperature of 2·10 K. A persistent current was induced in the loop by means of an electromagnet and the magnitude of the magnetic field produced as a result of that current was measured before and after an interval of 3 hr. ($\simeq 10^4$ sec.). The accuracy of measurement of the magnetic field was limited by noise in the probe to 1 part in 50, but no decay in the persistent current outside this limit could be observed. Therefore the time constant in the superconducting state must be greater than 50×10^4 sec. and the ratio $R_S/R_N = (L/R_N)/(L/R_S)$ is less than 2×10^{-16}. The corresponding resistivity in the superconducting state is less than 10^{-21} ohm cm. This is quite close to the upper limit obtained by Collins, but due to the use of an alloy my figure for the ratio R_S/R_N is probably about one order of magnitude smaller.

I thank Dr. E. H. Rhoderick of this Laboratory for suggesting the experiment and for his helpful advice, and also the Admiralty for permission to publish this communication.

R. F. Broom

Services Electronics Research Laboratory,
Baldock, Herts.

[1] Quoted by Crowe, J. W., *I.B.M. J. Res. and Development*, **1**, 294 (1957).
[2] Kronick, H. E., *I.B.M.J. Res. and Development*, **2**, 252 (1958).

Flow of Visco-Elastic Liquids from Tubes

It is frequently observed that when a visco-elastic fluid issues from a tube that the diameter increases as the fluid moves away from the tube exit.

To eliminate gravitational effects, consider the fluid flowing horizontally from a tube. It may be shown that if horizontal momentum is conserved, the diameter of the emerging jet should decrease as the material moves away from the tube exit. Since the diameter often increases with a visco-elastic liquid, it is deduced that momentum is not conserved and that there should be a force acting on the fluid. If this is the case, there should be an equal and opposite force acting on the apparatus from which the fluid flows.

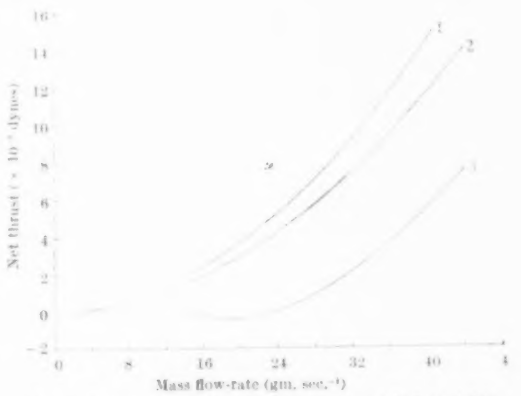


Fig. 1. Graphs of net thrust versus mass flow-rate for octal in paraffin 3/16-in. diam. tubes. Curve 1, calculated from cone and plate viscometer data; curve 2, calculated for flat velocity profile; curve 3, observed experimental results

Results of some experiments to test these ideas are shown on Fig. 1, on which is plotted the net thrust exerted by the flowing liquid on the apparatus versus the mass flow-rate. Curve 3, the observed net thrust, is unusual in that no net thrust is noted below a certain mass flow-rate. The net thrust then becomes negative and finally positive, but is much less than the calculated value.

It is well known that these fluids have a non-Newtonian distribution of normal stresses, and the results appear to show a measurable tensile force acting along the stream lines.

The same type of force seems to be present in the flow of solutions of aluminium laurate.

It was interesting to note that the apparatus moved in the same direction as the motion of the fluid when the net thrust was negative.

J. Harris

Chemical Engineering Department,
University College of Swansea.

Inelastic Scattering of Conduction Electrons in Dilute Silver–Manganese Alloys at Low Temperatures

The method of Grueneisen–De Haas was recently employed by me[1] for the analysis of our thermal and electrical resistivity data at helium temperatures[2] on dilute silver–manganese rods (containing, respectively, 0·55, 0·32 and 0·14 atoms per cent of manganese in random solid solution) in transverse magnetic fields ranging from 0 to 25 kilogauss. This method of analysis yielded information regarding the variation of the electronic Lorenz parameter L_e with the magnetic field and the temperature, while, at the same time, effecting the separation of the measured thermal conductivity into its electronic and lattice components.

I wish to direct special attention to a result of that analysis: namely, that L_e, at liquid helium temperatures, dipped below the normal Sommerfeld value L_n ($= 2{\cdot}45 \times 10^{-8}$ watt-ohm-deg.$^{-2}$), attained a minimum, and approached the value L_n at temperatures close to 0° K.

In order to explain their own results (following those of Gerritsen and Linde[3]) on the electrical resistivity maximum in the case of dilute alloys of a noble metal with a small amount of a transition metal, Schmitt and Jacobs[4] discussed the effects of inelastic impurity scattering of the conduction electrons[5,6]. Since a co-operative magnetic transition is known to occur[7–9] in such alloys, in this temperature region, the spin degeneracy of the impurity ion is thereby removed and the scattering process involving the spin flips of the conduction electron and the ion becomes inelastic[4,10].

The critical test for the existence of such an inelastic scattering would be in the thermal resistivity[11]. The 'vertical' transitions of the electrons, to which heat conductivity is very sensitive, would result in an anomalous contribution to the electronic thermal resistivity. My results for the electronic thermal resistivity (w_e) of these alloys do exhibit this behaviour. The plots of w_eT against T show this in the form of a pronounced 'peak'.

Taking $f = [(\rho_m/\rho_0) - 1]$, (where ρ_m stands for the value of the electrical resistivity maximum and ρ_0 for the value at $T \to 0$), as a measure of the maximum fractional contribution of inelastic impurity scattering, I obtain an estimated $f \approx 0{\cdot}1$, in my silver–manganese rod specimens. This ignores any temperature-dependent contribution from elastic scattering by the impurity ions[10].

For making the corresponding estimates in the case of the electronic thermal resistivity in these specimens, I write, $f' = [\{(w_eT)_m/(w_eT)_0\} - 1]$. Here, $(w_eT)_m$ and $(w_eT)_0$ stand for the values at the 'peak' and at $T \to 0$, respectively. From my plots of w_eT versus T, we obtain $f' \approx 0{\cdot}5$, $0{\cdot}6_5$ and $0{\cdot}8$, in the order of decreasing manganese content.

The fact that inelastic impurity scattering makes such a large contribution to the electronic thermal resistivity of these alloys, while making only a small contribution to the electrical resistivity, accounts for the 'dip' in the value of L_e with respect to the normal value L_n. The further result that L_e seems to approach L_n at temperatures close to absolute zero (below $\approx 1°$ K.) is explained by the fact that this inelastic scattering cannot occur at 0° K. Scattering, which would involve loss of energy by the electron, is not permitted since there are no lower electronic states available; scattering which would involve gain of energy by the electron is also not possible since there are no ions in the excited states at 0° K. to transfer energy to the electron.

Full details will be published elsewhere.

Grateful acknowledgment is made of the benefit of discussions with Sir K. S. Krishnan, Director of the National Physical Laboratory of India.

M. S. R. Chari

Low Temperature Section,
National Physical Laboratory of India,
New Delhi, 12.

[1] Chari, M. S. R., *Nature*, **189**, 824 (1961).
[2] Chari, M. S. R., Thesis, Leyden (1956). Chari, M. S. R., and De Nobel, J., *Physica*, **25**, 60 (1959); *Leyden Comm.*, No. 313b.
[3] Gerritsen, A. N., and Linde, J. O., *Physica*, **17**, 573 (1951); *Leyden Comm.* No. 285c.
[4] Schmitt, R. W., and Jacobs, I. S., *J. Phys. Chem. Solids*, **3**, 324 (1957).
[5] Kotringa, J., and Gerritsen, A. N., *Physica*, **19**, 457 (1953); *Leyden Comm.*, Supp. No. 106.
[6] Yosida, K., *Phys. Rev.*, **106**, 893 (1957).
[7] Owen, J., Browne, M. E., Arp, V., and Kip, A. F., *J. Phys. Chem. Solids*, **2**, 85 (1957).
[8] Schmitt, R. W., and Jacobs, I. S., *Canad. J. Phys.*, **34**, 1285 (1956).
[9] Jacobs, I. S., and Schmitt, R. W., *Phys. Rev.*, **113**, 459 (1959).
[10] Schmitt, R. W., *Phys. Rev.*, **103**, 83 (1956).
[11] Ziman, J. M., *Electrons and Phonons*, 382 (Clarendon Press, Oxford, 1960).

Breakdown Strength of Cæsium Iodide

Two crystal structures, both cubic, are found in the alkali halide group of compounds: (1) the 'sodium chloride type' of interpenetrating face-centred cubes, and (2) the 'cæsium chloride type' of interpenetrating simple cubes. All the group except cæsium chloride, cæsium bromide and cæsium iodide resemble sodium chloride at ordinary temperatures and pressures[1]. Measurements of the breakdown strength of halides of the sodium chloride type have shown[2] that there exists a simple relationship between the breakdown field strength, F, and the interionic distance, a, given by $Fa^2 = 28(\pm 25$ per cent) where F is measured in MV./cm. and a in Å. No previous work on the cæsium chloride type of halide has come to our notice.

In the course of some work on electro- and photoluminescence of crystals, the opportunity was taken to establish whether cæsium iodide obeyed this relationship. The crystals used contained about 0·1 per cent thallium (to make them better scintillators). This presence of foreign ions may raise the breakdown strength slightly above that of the pure crystal[3], but it is unlikely that the increase will be greater than experimental error.

Two single crystals of cæsium iodide were used, each approximately 0·01 cm. thick. For this thickness, it is to be expected that 'intrinsic' breakdown will take place[4]. In one method of procedure, an aluminium point contact was used as one electrode and a metal plate the other, while in a second method a metal sphere of diameter 3 mm. was used as the first electrode. A film of water usually forms on cæsium iodide crystals and results in discharges around the edges. This was prevented by polishing the crystals in oil and keeping an oil film on the crystals during the experiments.

Over a series of experiments at room temperature using the first method, breakdowns occurred at fields which varied from experiment to experiment, due probably to the presence of local flaws in the crystal structure, the minimum and maximum fields at which breakdown occurred being 0·29 and 0·36 MV./cm.

With the second method, the corresponding limits were 0·20 and 0·40 MV./cm., and the average value was 0·32 (±0·05) MV./cm.

The interionic distance for cæsium iodide is 3·95 Å. (ref. 5). Then for this crystal $Fa^2 = 20 \pm 3$, in reasonable agreement with the value found for the sodium chloride type of crystal structure.

R. Taagepera
R. S. Storey
K. G. McNeill

Department of Physics,
University of Toronto,
Toronto 7, Ontario.

[1] Pauling, L., *The Nature of the Chemical Bond*, 519, third ed. (Cornell Univ. Press, 1960).
[2] Franz, W., *Encycl. Phys.*, **17**, 249 (Springer-Verlag, Berlin, 1956).
[3] Von Hippel, A., and Lee, G. M., *Phys. Rev.*, **59**, 824 (1941).
[4] O'Dwyer, J. J., *Advances in Physics*, **7**, 349 (1958).
[5] Wyckoff, R. W. G., *Crystal Structures*, **1**, Table III, 7 (Interscience Publ., New York, 1948).

ASTROPHYSICS

Trajectories of Chromospheric Disk Surges

As a result of the use of rapid sequence *H*-alpha cinematography, Lockheed Solar Observatory has collected a large quantity of data on disk surges during 1959 and 1960. Since January 1960, the band pass of the birefringent filter has been displaced 0·5 Å. to the blue or red of *H*-alpha. The increased contrast between active absorption features and the background in the wings of *H*-alpha has resulted in a greater ability to detect disk surges. The percentage of flares of all classes associated with observed surges increased from 11·4 per cent in 1959 to 20·4 per cent in 1960. Approximately 94 per cent of the total flares were sub-flares. During the two years, a total of 953 flare surge events were photographed at the Observatory.

The study of surges observed in the wings of *H*-alpha has permitted the identification of a new class of disk surges which are characterized by extremely intricate structures. Unlike the 'classical' disk surges which appear as straight brush-like extensions from flares[1], these dark surges, which we term 'complex surges', appear on single frames as irregular, dark mottles. Although material is clearly being ejected with typical velocities of 100 km./sec., the complex surges show little preferential direction of flow and have trajectories seemingly dominated by local force fields. Table 1 lists three large complex surges observed in 1960.

Table 1

Date 1960	Time Start (U.T.)	Time Max.	Extension	Mean velocity (km./sec.)	Associated position	Flare importance
May 9	0030	0052	0·13 R	69	S. 11 E. 04	1
Sept. 25	1817	1855	0·30 R	92	S. 18 W. 22	1
Nov. 20	1640	1655	0.19 R	77	N. 23 W. 45	1–

While viewing the off-band films of these events, particular attention was paid to the motion of the complex surges relative to the neighbouring bright coarse mottling. It was found that whenever the direction of flow was altered the dark surge material appeared to avoid the bright mottling. The surges with very complex structure were deflected many times as the surge material appeared to flow along the lanes between the bright mottling.

The complicated trajectories of these surges may perhaps be understood in terms of magnetic fields in the coarse mottling. The kinetic pressure of surge material moving with a speed of 100 km./sec. with a density of 10^{11} protons per cm.^{3} would be balanced by the magnetic pressure of a field of about 20 gauss. The correspondence between magnetic fields of such magnitude and CaII plages was first established by the Babcocks[2], and has recently been corroborated by Howard[3] and Leighton[4]. The boundaries of CaII plages appear to be contained by 10 gauss contours and the fields in such plages may reach as high as 200 gauss. The wings of *H*-alpha are not formed at the same height of the chromosphere as the centre of the CaII *K* line; however, bright mottling in the wings of *H*-alpha and CaII plages may well correspond to different heights in the chromosphere along continuous vertical magnetic columns.

Detailed work on the association between magnetic fields and the coarse mottling in the wings of *H*-alpha is needed; but it does appear that bright mottling is adjacent to large field gradients. Chromospheric filaments apparently lie between regions of opposite polarity[2], and when filaments are visible in the wings of *H*-alpha, they are generally bordered by bright mottling apparently identical to that which deflects the surges. Further work on the trajectories of disk surges is continuing as the observations reported here suggest that surges may be utilized as 'test particles' for the mapping of chromospheric and coronal magnetic fields.

J. M. Malville

High Altitude Observatory,
Department of Astro-Geophysics,
University of Colorado,
Boulder, Colorado.

G. E. Moreton

Lockheed Solar Observatory,
Lockheed Aircraft Corporation,
Burbank, California.

[1] Giovanelli, R. G., and McCabe, M. K., *Austral. J. Phys.*, **11**, 191 (1958).
[2] Babcock, H. W., and Babcock, H. D., *Astrophys. J.*, **121**, 349 (1955).
[3] Howard, R., *Astrophys. J.*, **130**, 193 (1959).
[4] Leighton, R. B., *Astrophys. J.*, **130**, 366 (1959).

GEOLOGY and MINERALOGY

Origin of Ignimbrites

A field and laboratory study of the Ordovician ignimbrites of North Wales that has been in progress since 1953[1–3] has revealed certain limitations in Marshall's original hypothesis[4] regarding the origin of this interesting category of rocks. These limitations have been apparent to workers elsewhere[5–8]. The evidence from North Wales, and much of the published evidence from North and South America, is categorically opposed, however, to the hypothesis of origin now proposed by Steiner[9]. As this new hypothesis is based on a petrological study of the type ignimbrites from the North Island of New Zealand, and involves the far-reaching conclusion that liquid immiscibility plays a large part in the petrogenesis of acid igneous rocks, a critical appreciation of Steiner's views is urgently required. A detailed petrological criticism is in preparation, and will be published in full elsewhere. In the meantime, it is appropriate to state that Steiner's conclusions appear to be based on a

misinterpretation of the evidence afforded by the New Zealand rocks.

Steiner correctly observed the presence of two contrasting glasses in fresh New Zealand ignimbrites—a feature of certain ignimbrites mentioned by other authors[10,11]. Ancient ignimbrites, such as those from North Wales, cannot contain unaltered glass, but they do retain, in many instances, the textural evidence of its former presence. It is on the textural evidence derived from a comparison of North Welsh rocks with unaltered New Zealand specimens that Steiner's hypothesis of liquid immiscibility is rejected. The presence of two, and, rarely, of three, distinct glasses appears to be an accidental feature of certain ignimbrites, and not of universal importance. In some fresh New Zealand ignimbrites, fragments and shreds of juvenile glass can be seen to enclose rounded and partly resorbed xenoliths of earlier glassy ignimbrites and vitric tuffs, along with globular masses of a similar shape and size of another glass of higher refractive index. The conclusion that this second glass did not originate by liquid immiscibility, but is present as small xenoliths, is amply confirmed by the occasional presence of much larger angular xenoliths of the same glass, containing resorbed phenocrysts. In other instances the accessory xenolithic origin of the small globular masses of the second glass is not so readily obvious, but, once its characteristic features have been defined by study of unambiguous examples, the general identity of origin of the second glass can be confidently accepted. The peculiar groupings and matching shapes, within patches of small globules of this second glass, are clearly related to the partial resorption and separation of the perlitic fragments of an earlier obsidian. Vent-rocks from North Wales, and large fragments contained within ignimbrites, both from New Zealand and North Wales, often have very intricate textural patterns, produced by the plastic distortion of hot obsidian containing numerous gas vesicles and dissolving xenoliths of earlier glass. It is the texture shown by rocks of this type that has misled Steiner.

Steiner observed that the second glass has a higher refractive index than the juvenile glass. This can be confirmed, and indeed is to be expected, if the second glass were present as reheated and partially dissolved fragments of an earlier obsidian that consolidated within or below the volcanic vent, for this would be derived from either an earlier volatile-poor fraction of the present magmatic phase, or from a magma less advanced along the differentiation sequence.

Much of the textural evidence described by Steiner from New Zealand ignimbrites can be studied equally well in North Welsh rocks. The phenocrysts of ignimbrites, for example, cannot be described as generally showing multiple resorption features. The vast majority of the felspar phenocrysts are obviously broken and abraded by gas-generated expansion, and only the rare quartz phenocrysts preserved within xenolithic obsidian lumps show that intricate resorption outline regarded by Steiner as evidence for gentle flow rather than a violent expansion of gas. Any resorption of phenocrysts occurred mainly before eruption.

The conclusion of Hausen that ignimbrites are more akin to lavas in their mode of origin than to pyroclast-showers is one that most workers in the field would support, but the field and petrographic evidence is definitely opposed to the view that they are true lavas. There may be, in fact, every gradation from the 'boiling milk' gas-liquid emulsion suggested by Lacroix[12] to a *nuée ardente* of gas-lubricated pyroclasts, but the majority of welded ignimbrites fall between these two extremes, and, as Marshall suggested, their textures indicate gravity collapse and mutual adherence of hot plastic glass fragments of all sizes, deposited from suspension in an incandescent gas stream. (The analogy with turbidity current deposition in marine sedimentation is obvious.) The many flattened glass bubbles seen in both the New Zealand and Welsh rocks confirm this hypothesis. The flattened lenticles common in many ignimbrites are mostly accessory obsidian xenoliths. Only in the largest and most widespread flows can the suspicion be entertained that any of the inclusions are composed of collapsed glass-froth. The Pitt's Head ignimbrite of the Pass of Llanberis, North Wales, is one such example.

With the further accumulation of our knowledge of acid volcanism it seems likely that an analogy with the work of Jagger[13] on basic magmas may become possible. Welded ignimbrites appear to be the product of a fluent gas-generating acid equivalent of basic pyromagma, the lenticles contained in them being consolidated fragments of an acid equivalent of basic bench—or epimagma. The difference between sillars and welded ignimbrites may be analogous to the difference between pahoehoe and aa-flows. The principal difficulty facing workers on ignimbrites is that nowhere has the deposition of a welded ignimbrite been observed. The evidence from field and microscopic examination of these rocks leaves no doubt, however, that the difference between the average ignimbrite flow and the observed *nuées ardentes* is principally one of degree depending on the state and quantity of the erupting magma. Always there is overwhelming evidence that gas is the active agent—liquid immiscibility finds no place in the mechanism of ignimbrite formation.

F. J. Fitch

Geology Department,
Birkbeck College,
London, W.C.1.

[1] Rast, N., Beavon, R. V., and Fitch, F. J., *Nature*, **181**, 508 (1958).
[2] Rast, N., Fitch, F. J., and Beavon, R. V., *Proc. Geol. Soc., Lond.*, **116**, 1571 (1959).
[3] Beavon, R. V., Fitch, F. J., and Rast, N., *Liverpool and Manchester Geol. J.*, **2**, 600 (1961).
[4] Marshall, P., *Trans. and Proc. Roy. Soc., N.Z.*, **64**, 323 (1935).
[5] Hausen, D. M., *Bull. Geol. Soc. Amer.*, **65** (2), 1361 (1954).
[6] MacGregor, A. G., *Nature*, **157**, 305 (1946).
[7] Kennedy, G. S., *Geol. Soc. Amer. Spec. Paper*, **62**, 489 (1955).
[8] Beck, A. C., and Robertson, E. I., *N.Z. Dep. Sci. Indust. Res. Bull.*, **117**, 15 (1955).
[9] Steiner, A., *N.Z. Geol. Surv. Bull.*, 68 (1960).
[10] Weinschenk, E., and Clark, R. W., *Petrographic Methods*, 222 (1912).
[11] Williams, H., *Univ. Calif. Pub. Geol. Sci.*, **29**, 145 (1952).
[12] Lacroix, A., *Jub. Volume Soc. Geol. France*, **2**, 460 (1930).
[13] Jagger, T. A., *U.S. Nat. Res. Council Bull.*, **77**, 44 (1936).

Skiddaw Slates proved in the Teesdale Inlier

The small inlier of Lower Palæozoic rocks in Upper Teesdale crops out beneath Carboniferous strata in the banks of the River Tees below Cronkley Scar near the hamlet of Langdon Beck, Co. Durham. The inlier is poorly exposed, but consists of an eastward belt of soft greenish and light-coloured highly cleaved slates, until recently regarded as completely unfossiliferous, and a western area in which exposures of lava occur. The slates are best exposed in the old workings near the Pencil Mill (*NY*[35]849296) where

at one time the softer beds were worked up into slate-pencils.

The Teesdale Inlier was discovered in the latter part of the last century when the highly cleaved slates were described as probably Skiddaw Slates, Lower Ordovician, by Dakyns[1] in 1877. A further account of the inlier in 1878 by Gunn and Clough[2] referred the slates tentatively to the Silurian Stockdale Shales. Later authors followed Gunn and Clough in regarding the slates as probably Silurian until Kendall and Wroot[3] revived the view that they were better placed in the Skiddaw Slate Series, and this latter view was supported by Dunham[4]. Five mica-lamprophyre dykes are intruded into the slates in the vicinity of the Pencil Mill and have been described by Williams[5]. The lavas at the western end of the Inlier are tentatively referred to the Borrowdale Volcanic Series.

The first fossils to be found in the slates of the inlier were collected near Pencil Mill by Mr. G. F. Lea during a Durham undergraduate geological mapping exercise in the spring of 1959. The specimens consisted of poorly preserved graptolites which were not found *in situ*. Several subsequent visits to the inlier in search of further graptolites were unsuccessful, but some small elongated thin-shelled fossils were obtained which are believed to be phyllocarid crustacean carapaces and tentatively referred to ? *Caryocaris* sp. On a further recent visit to the inlier three more graptolites were obtained from slate scree in the Pencil Mill workings and the preservation of these specimens is more definite. It is noteworthy that all the fossils found in the slates of the inlier are inconspicuous to the naked eye, and it is undoubtedly owing to this that they have remained undiscovered until the last few years.

The graptolites found in the Teesdale Inlier have been examined by Prof. O. M. B. Bulman, who has made tentative identification of the specimens as follows: ? *Cryptograptus* sp.; *Glyptograptus dentatus* (Brongn.); *Didymograptus* sp., the proximal end of a pendent didymograptid, possibly *D. climacograptoides* Holm MS. (Bulman).

This fauna, particularly the presence of pendent didymograptid in association with *G. dentatus*, is sound evidence of Lower Ordovician age and shows that the beds belong to the upper part of the Skiddaw Slate Series. Prof. Bulman suggests that the slates of the Teesdale Inlier may in fact be an easterly extension of the Ellergill Beds, the central division of the Skiddaw Slates of the Cross Fell Inlier. The presence of ? *Caryocaris* sp. in the Teesdale slates is supporting evidence for Skiddaw Slates Series age. Thus the long-disputed question of the age of the slates of the Teesdale Inlier is finally solved by the discovery of a graptolite fauna.

The advice and assistance of Prof. O. M. B. Bulman and Mr. J. D. D. Smith, who kindly examined the graptolites and other fossils from the Teesdale Inlier, are gratefully acknowledged.

G. A. L. Johnson

Department of Geology,
University Science Laboratories,
South Road, Durham.

[1] Dakyns, J. R., *Proc. Yorkshire Geol. Soc.*, **6**, 239 (1877).
[2] Gunn, W., and Clough, C. T., *Quart. J. Geol. Soc. Lond.*, **34**, 27 (1878).
[3] Kendall, P. F., and Wroot, A. E., *The Geology of Yorkshire* (Vienna, 1924).
[4] Dunham, K. C., *The Geology of the Northern Pennine Orefield*, 1 (Mem. Geol. Survey Gt. Brit., 1948).
[5] Williams, D., *Proc. Liverpool Geol. Soc.*, **13**, 323 (1923).

Ekanite, a New Metamict Mineral from Ceylon

Since 1953, several specimens, the largest about 44 gm., of a green transparent–translucent mineral, which when cabochon-cut as a gemstone may show some asterism, have reached Europe. The mineral occurs in the gem pits of Eheliyagoda, Raknapura district, Ceylon, and was originally found there by Mr. F. L. D. Ekanayake, who suspected that it might be a new species. This has now been confirmed by chemical and physical study, of which the principal results are given here.

The mineral is metamict, and an analysis by Mr. D. I. Bothwell gave: SiO_2 55·6, ThO_2 27·6, UO_2 2·1, Fe_2O_3 0·5, CaO 13·7, PbO 0·8 per cent, with traces of Al_2O_3, MgO, MnO, total 100·3 per cent, yielding the formula:

$$(Th,U)(Ca,Fe,Pb)_2Si_8O_{20}$$

The refractive index and density of the mineral as found are 1·5969 and 3·280 respectively. After heating at 510° C. for 24 hr. these constants fall to 1·5933 and 3·276.

At temperatures between 650° and 1,000° C., the mineral re-crystallizes to a phase of which X-ray powder and single-crystal diffraction patterns can be indexed on the basis of a body-centred tetragonal cell having dimensions a 7·46, c 14·96 Å. The density after heating at 1,000° C. for 24 hr. rises to 3·313 and the mineral becomes opaque putty-coloured.

Heating at higher temperatures involving re-melting leads to the development of the thorium silicate, huttonite. If the mineral is fully melted and then re-crystallized at 1,000° C., the product appears to be a thorium analogue of the britholite–lessingite–cerite group[1].

Besides some microscopic inclusions parallel to two directions at right angles, ekanite contains occasional larger opaque inclusions not yet identified with certainty.

The mineral is named after the discoverer. A full account will be published elsewhere.

B. W. Anderson

The Laboratory of the
London Chamber of Commerce,
15 Hatton Garden, London, E.C.1.

G. F. Claringbull
R. J. Davis

Department of Mineralogy,
British Museum (Natural History),
London, S.W.7.

D. K. Hill*

Department of Glass Technology,
University of Sheffield.

*Present address: British Indestructo Glass, Ltd., London, N.W.10.

[1] Gay, P., *Min. Mag.*, **31**, 455 (1957).

METALLURGY

Arc Initiation on Heated Metals by a Hydrogen Discharge

An undesirable phenomenon of importance to experimental investigations of toroidal pinched gas discharges is the formation of unipolar and power arcs at metallic parts of the system exposed to the plasma[1]. Previous work[2,3] has indicated the important part played by insulating inclusions in metals in the process of arc initiation under these conditions. We are investigating the arcing characteristics of refractory metals, exposed to a toroidal discharge in pure

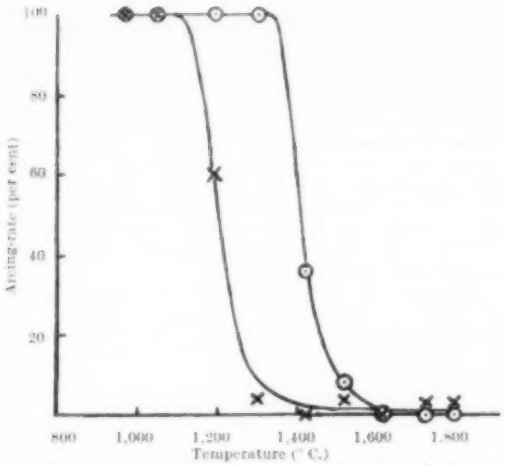


Fig. 1. Arcing-rate as a function of temperature for molybdenum at 2 kV., 16 amp./cm.². ○, Temperature increasing; ×, temperature decreasing

hydrogen, as a function of temperature. The results so far obtained support the hypothesis that arcs are initiated through the agency of second phases.

The metals tungsten, tantalum and molybdenum, in the form of wires of commercial purity, are biased negatively with respect to the plasma at up to 2 kV. Mean ion current densities of up to 16 amp./cm.² are drawn from the discharge for a period of 200 μsec. The temperature of the wires can be varied by direct electrical heating. There is, in addition, some heating from the discharge (due mainly to ions drawn during the pre-ionizing period) which sets a lower limit to the temperature depending on the biasing voltage (730° C. at 1 kV., 970° C. at 2 kV.). It is found that arcing tends to occur when the wires are cool but not when hot, even though the temperature is sufficiently high for thermionic emission. Fig. 1 shows the arcing rate (percentage discharges in which an arc occurs) as a function of temperature for molybdenum at 2 kV., 16 amp./cm.².

It is clear that a marked transition from an arcing state to a non-arcing state occurs during both heating and cooling. The transitions are attributed to: (*a*), on heating, the solution of second phases; (*b*), on cooling, their precipitation. This interpretation is supported by quenching experiments on molybdenum. If the wire is first heated to the non-arcing state and then cooled quickly (by radiation) it does not arc initially at ambient temperature (970° C.), but de-conditions to the arcing state after a further period of discharges. Thus the quenching treatment retains a supersaturated solution of impurities which, however, gradually precipitate at the ambient temperature.

We find that the arcing characteristics change slowly during the course of experiments on a particular wire. Arcing tends to occur less readily in the later stages of the tests, particularly at low voltages. This behaviour is attributed to the loss from the wire of the arc-initiating phases. The mechanism by which this occurs is believed to be essentially that which initiates an arc. A second-phase particle on the surface is charged up by the incoming positive ions until an electrical breakdown occurs. The energy released during the breakdown is sufficient to evaporate at least a portion of the particle. The puff of vapour so released can initiate an arc if of sufficient size and if the electric field is of sufficient strength. If, however, these requirements are not met, a simple loss of impurity occurs at the surface. Thermal cycling will, however, tend to replenish the depleted surface layer by diffusion of impurities from the interior. This hypothesis is supported by experiments on molybdenum at less-severe electrical conditions than those mentioned above. Thus at 1·7 kV., 8 amp./cm.², the arcing-rate passes through a maximum at about 1,050° C., during heating and again on cooling. At low temperature, therefore, the competition between surface depletion and precipitation is won by the former due to low diffusion-rates.

We have made use of the depletion process to prepare molybdenum wires which are virtually non-arcing at any temperature in the range 700–1,800° C. The procedure adopted is to cool the wire slowly from 1,800° C. while at the same time exposing it to an uninterrupted series of discharges at the maximum electrical conditions of 2 kV., 16 amp./cm.². Very little arcing occurs during this process if the cooling-rate is sufficiently slow; the surface particles are therefore evaporated before they grow big enough to start an arc. After several such operations no arcing can be induced by extended heat treatment aimed at homogenizing the wire to encourage surface precipitation. It seems likely therefore that the wire is depleted throughout its volume by this method.

These observations suggest that the conditioning of various metals against arcing at room temperature observed by Craston *et al.*[1] is due to the depletion at the surface of insulating inclusions.

A detailed report is to be published elsewhere.

J. T. Maskrey
R. A. Dugdale
R. C. McVickers

Metallurgy Division,
Atomic Energy Research Establishment,
Harwell, Berks.

[1] Craston, J. L., *et al.*, *Second U.N. Int. Conf.*, *P/34* (Geneva, 1958).
[2] Pfeil, P. C. L., and Griffiths, L. B., *J. Nucl. Mat.*, **3**, 244 (1959).
[3] Hancox, R., *Brit. J. App. Phys.*, **11**, 468 (1960).

CHEMISTRY

Prevention by Cysteamine of Radical Formation in Bovine Serum Albumin by γ-Rays

Cysteamine is one of the most effective substances for the protection of animals against ionizing radiations, and *in vitro* has been shown to reduce radiation damage of macromolecules by energy transfer in solid polymethylmethacrylate[1], by capture of $OH^{\cdot}$ radicals for serum albumin in dilute solution[2], and by hydrogen transfer to an organic radical for polymers in aqueous solution[3,4]. Gordy and Miyagawa[5] have found that the electron spin resonance spectrum of the protein zein is altered in magnitude and character if cysteamine is present, and have ascribed this to the combination of cysteamine with the protein by a disulphide exchange reaction. Earlier experiments[1] led us to believe that an energy-transfer process is a more probable mechanism of protection, and to test this hypothesis we studied the effect of cysteamine on the electron spin resonance spectrum of bovine serum albumin irradiated with cobalt-60 γ-rays at room temperature and at 77° K. (dose, 5 Mrads, dose-rate = 750 krads/hr.). The mixture of 90 per cent bovine serum albumin + 10 per cent cysteamine was produced

by freeze-drying a solution. Although bovine serum albumin contains 17 disulphide groups per molecule, none of these reacts with cysteamine under isoelectric conditions because they are sterically inaccessible[6,7] and the possibility of protection by disulphide exchange is therefore excluded (human serum albumin combines with cysteamine at the isoelectric point because one disulphide bond is reactive[7]).

A 400 kc./s. magnetic field modulation *X*-band spectrometer was used. The samples were placed in an H_{011} transmission-type cavity. The source of microwave power was a low-voltage reflex *K*302 klystron, and crystal detection employing a *CV*2154 crystal was used. A maximum linear sweep amplitude of about 200 gauss was obtained using an electronic 'bootstrap' type linear sawtooth generator. Thus all spectra were recorded as the first derivative of the absorption intensity as a function of variation in magnetic field with the microwave frequency held constant. At maximum usable sensitivity, 7×10^{14} radicals in α,γ-diphenyl β-picryl hydrazyl could be detected at room temperature.

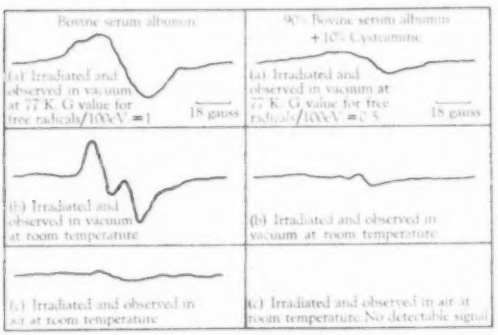

Bovine serum albumin
90% Bovine serum albumin + 10% Cysteamine
(a) Irradiated and observed in vacuum at 77° K. G value for free radicals/100eV = 1
18 gauss
(a) Irradiated and observed in vacuum at 77° K. G value for free radicals/100eV = 0·5
18 gauss
(b) Irradiated and observed in vacuum at room temperature
(b) Irradiated and observed in vacuum at room temperature
(c) Irradiated and observed in air at room temperature
(c) Irradiated and observed in air at room temperature. No detectable signal

Fig. 1. Electron spin resonance spectra of bovine serum albumin and a mixture of 90 per cent bovine serum albumin + 10 per cent cysteamine under various conditions. All spectra recorded at the same spectrometer sensitivity

Fig. 1 shows that the presence of 10 per cent of cysteamine reduces the intensity of the electron spin resonance spectrum of bovine serum albumin whether the irradiation is carried out at 77° K., at room temperature *in vacuo*, or at room temperature in air. The nature of the electron spin resonance spectrum is different under these three conditions, but in every case cysteamine has the same effect, namely, to reduce to half or less than half the number of radicals that are formed. In each case the same weight of cysteamine on its own gives no signal. Measurements at 77° K. presumably reveal all the radicals that are produced on irradiation, while electron spin resonance at room temperature measures those radicals that for steric reasons have been unable to recombine.

The protection by cysteamine seen in the room-temperature measurements could be due either to energy transfer from the proteins to the cysteamine before a radiochemical reaction occurs, or due to hydrogen transfer leading to a reconstitution of the protein radical ($R^{\cdot}$):

$$R^{\cdot} + \text{SH—} \rightarrow RH + \text{S}^{\cdot} \quad (2\,\text{S}^{\cdot} \rightarrow \text{—S.S—})$$

The electron spin resonance signal of the mixture at room temperature is small and a choice between the two mechanisms is not possible.

This hydrogen transfer 'repair' mechanism (cf. refs. 3 and 4) cannot, however, apply at 77° K., since the radicals are effectively frozen and prevented from reacting, and the observed protection must therefore be ascribed to an energy-transfer process similar to that originally observed in synthetic polymers. Moreover, the electron spin resonance spectrum of the mixture at 77° K. is qualitatively the same as that of bovine serum albumin alone. This confirms that the bovine serum albumin has been protected by transfer of energy to the cysteamine rather than by a chemical reaction, which would probably give rise to a signal in the mixture different from that for bovine serum albumin alone. There seems to be no reason for limiting this interpretation to bovine serum albumin and we feel that the disulphide exchange reaction need not be involved in the protection of other proteins by sulphydryl compounds, in particular since our electron spin resonance experiments with irradiated cystine and bovine serum albumin (Libby, D., Ormerod, M. G., and Alexander, P., unpublished work) do not lead us to the conclusion of Gordy, Ard and Shields[8] that radicals induced by irradiation are chiefly associated with the sulphur atoms to which the energy deposited in other parts of the protein molecule migrate. The electron spin resonance pattern of bovine serum albumin irradiated at 77° K., when all the radicals are still present, bears no resemblance to that of irradiated cystine.

Our experiments lead us to question the hypothesis[9] that disulphide exchange plays a part in the protection of animals against radiation by cysteamine, since this mechanism need not be invoked to account for the protection of proteins *in vitro*, whether this occurs directly or by capture of $\overset{\cdot}{O}H$ radicals formed in water[2].

D. Libby
M. G. Ormerod
A. Charlesby

Physics Branch,
Royal Military College of Science,
Shrivenham, nr. Swindon, Wilts.

P. Alexander

Chester Beatty Research Institute,
Royal Cancer Hospital, S.W.3.

[1] Alexander, P., Charlesby, A., and Ross, M., *Proc. Roy. Soc.*, **A**, **223**, 392 (1954).
[2] Rosen, D., Brohult, S., and Alexander, P., *Arch. Biochem. Biophys.*, **70**, 266 (1957).
[3] Alexander, P., and Charlesby, A., *Symp. Radiobiol.*, Liège (Butterworths, London, 1955.)
[4] Charlesby, A., and Alexander, P., *J. Chim. phys.*, **52**, 699 (1955).
[5] Gordy, A., and Miyagawa, I., *Rad. Res.*, **12**, 211 (1960).
[6] Markus, G., and Karush, F., *J. Amer. Chem. Soc.*, **79**, 134 (1957).
[7] Alexander, P., and Hamilton, L. D. G., *Arch. Biochem. Biophys.*, **88**, 128 (1960).
[8] Gordy, W., Ard, W. B., and Shields, H., *Proc. U.S. Nat. Acad. Sci.*, **41**, 983 (1955).
[9] Eldjarn, L. Pihl, A., and Shapiro, B., *Proc. Int. Conf. Peaceful Uses Atomic Energy*, **11**, 335 (1955).

Behaviour of Magnesium Impurity in Gallium Arsenide

Anomalous behaviour of magnesium in gallium arsenide has been reported by Edmond[1] and Weisberg *et al.*[2], who found that magnesium behaves as a donor impurity, differing in this respect from zinc, cadmium and mercury. Edmond incorporated $5{\cdot}7 \times 10^{19}$ atoms/cm.^{3} of magnesium in his specimens and found it to be a donor impurity ; however, Weisberg found magnesium to be a donor when present at low concentration, but an acceptor at levels higher than $4{\cdot}4 \times 10^{18}$ atoms/cm.^{3}. The experimental methods

employed by Weisberg are not known to me; however, Edmond prepared his specimens by heating gallium arsenide and magnesium together in sealed silica tubes for 1 hr. at 1,551° K., a small quantity of arsenic being added to prevent decomposition.

Two specimens were prepared in these Laboratories by the method described above. As they had similar properties, the calculations and work reported here relate to one of these samples only.

After cooling, a light grey stain was observed on the inner surface of the tube. This stain, which appeared over a small area only, was not removable by aqua regia and indicated reaction between the tube and its contents. The specimen was carefully etched to remove surface oxides and was compared spectrographically with the pure gallium arsenide from which it was prepared. The most sensitive lines of magnesium and silicon, barely visible for the pure arsenide, showed up strongly for the specimen. The ratio of silicon to magnesium was estimated to be somewhat greater than unity.

In order to determine the true behaviour of magnesium, a further specimen was prepared in a different manner. Gallium arsenide and magnesium were placed in a carbon container with a well-fitting lid. This container, together with the correct quantity of arsenic, was sealed within a silica tube and heated to 1,551° K. for a short time.

Spectrographic examination indicated a much smaller silicon content than in the other specimens. This specimen was *p*-type with $6{\cdot}1 \times 10^{18}$ acceptors/cm.^{3} compared with $5{\cdot}6 \times 10^{19}$ magnesium atoms/cm.^{3} which were incorporated by weighing. Magnesium, therefore, is an acceptor in gallium arsenide and probably occupies gallium lattice sites.

Reaction between magnesium and silica proceeds according to the general equation :

$$2Mg + SiO_2 = 2MgO + Si \qquad (1)$$

This implies that in experiments of this kind, a thin layer of magnesium oxide forms on the inner surface of the tube. The rate of reaction is limited by the rate at which fresh silica can reach the surface (by solid state diffusion), and the final ratio of silicon to magnesium in the melt is determined by the composition of the oxide phase in equilibrium with the melt.

At 1,551° K., the system $MgO - SiO_2$ has one stable intermediate phase Mg_2SiO_4, and another phase $MgSiO_3$ of marginal stability. The extra stability of Mg_2SiO_4 is − 15,120 cal./mole and large variations in the activities of MgO and SiO_2 are to be expected for $MgO : SiO_2$ ratios close to 2 : 1 (compare the treatment of system $CaO–SiO_2$ [4]).

For equilibrium with oxide phases having $MgO : SiO_2$ ratios less than 2, it is best to use the equation :

$$2Mg(l) + 2SiO_2(s) \rightleftharpoons Mg_2SiO_4(s) + Si(l) \qquad (2)$$

$$\Delta G^\circ = -83{,}980 + 2{\cdot}52\,T \log T - 4{\cdot}99T$$

$$= -79{,}250 \text{ cal. at } 1{,}551^\circ \text{ K.}$$

For equilibrium with oxide phases having $MgO : SiO_2$ ratios greater than 2, it is best to use :

$$2Mg(l) + Mg_2SiO_4(s) \rightleftharpoons 4MgO(s) + Si(l) \qquad (3)$$

$$\Delta G^\circ = -53{,}740 + 2{\cdot}52\,T \log T - 4{\cdot}99T$$

$$= -49{,}000 \text{ cal. at } 1{,}551^\circ \text{ K.}$$

In order to proceed further, it is necessary to know values of the activity coefficients of silicon and magnesium in gallium arsenide. These are not available and, as this is only an approximate treatment, ideal solution behaviour has been assumed for the purpose of these calculations. Liquid magnesium and undercooled liquid silicon are adopted as the standard states.

In the experiment carried out in these Laboratories, the amount of magnesium incorporated in the specimen was $5{\cdot}25 \times 10^{19}$ atoms/cm.^{3}.

Combining this information with a ΔG° value of − 79,250 cal. and, using the expression :

$$\Delta G^\circ = -RT \log_e \frac{x_{\text{silicon}}}{x^2_{\text{magnesium}}}$$

we obtain :

$$x_{\text{silicon}} = 1{\cdot}18 \times 10^{-3}$$

$$\text{ratio } \frac{x_{\text{silicon}}}{x_{\text{magnesium}}} = 1{\cdot}32 \times 10^{3}$$

$$x_{\text{magnesium}} = 8{\cdot}9 \times 10^{-7}$$

(where x is the mole fraction).

Alternatively, using a ΔG° value of − 49,000 cal. we obtain :

$$x_{\text{silicon}} = 1{\cdot}17 \times 10^{-3}$$

$$\text{ratio } \frac{x_{\text{silicon}}}{x_{\text{magnesium}}} = 95$$

$$x_{\text{magnesium}} = 1{\cdot}24 \times 10^{-5}$$

As silicon is a donor impurity in gallium arsenide, electrical behaviour, previously attributed to magnesium, may be explained by the process of chemical replacement described here. The specimens prepared in contact with silica were shown by thermal E.M.F. measurements to be *n*-type but the ratio $x_{\text{silicon}}/x_{\text{magnesium}}$ appeared to be less than the estimated value of 95.

Taking into account electronegativities of the atoms involved, and the stabilities of their compounds, it appears that the assumption of ideal behaviour is reasonably accurate for silicon but not for magnesium. Silicon has a structure similar to that of gallium arsenide and can substitute on either lattice site[5]. Each magnesium atom, by analogy with zinc or cadmium, should substitute on a gallium site and be surrounded tetrahedrally by four arsenic atoms. Magnesium also forms a stable arsenide, Mg_3As_2 (estimated heat of formation, − 90,000 cal./mole), in which each magnesium atom is bounded by four arsenic atoms as nearest neighbours. For this reason, the activity coefficient of magnesium in gallium arsenide should be considerably less than unity.

Equations (2) and (3) represent the limiting conditions likely to be encountered in experimental work. Ratios of $x_{\text{silicon}}/x_{\text{magnesium}}$ derived from them need to be reduced to allow for the non-ideality of magnesium. The extent of this reduction is not easy to estimate.

This work is being carried out under Admiralty contract *CP.4D(2)* 5298/58/60.2.

J. R. Knight

The Plessey Co., Ltd.,
Caswell Research Laboratories,
Towcester, Northants.

[1] Edmond, J. T., *Proc. Phys. Soc.*, **73**, Pt. 4, 622 (1959).
[2] Weisberg, L. R., Rosi, F. D., and Herkart, P. G., *Properties of Elemental and Compound Semiconductors*, **5**, edit. by Gatos, H. C., (Interscience Pub., New York, 1960).
[3] Kubaschewski, O., and Evans, E. Ll., *Metallurgical Thermochemistry* (Pergamon Press, 1958).
[4] Darken, L. S., and Gurry, R. W., *Physical Chemistry of Metals*, 341 (McGraw-Hill Book Co., New York, 1953).
[5] Kolm, C., Kulin, S. A., and Averbach, B. L., *Phys. Rev.*, **108**, 965 (1957).

Crystal Growth of Gallium Arsenide using Carbon Boats

GALLIUM arsenide is a semiconductor of great interest from the purely scientific point of view and as a device material. It is therefore desirable to be able to prepare single crystals of high purity. Because of the reactive nature of gallium liquid and arsenic vapour at high temperature, only a limited number of refractories may be used as boat materials for gallium arsenide (melting point, 1,511° K.). Among these are carbon, vitreous silica and alumina. In addition a sealed envelope of vitreous silica is generally employed to prevent the escape of arsenic vapour from the system.

It is observed that, in general, the use of carbon or carbonized silica boats facilitates single crystal growth, whereas ingots grown in silica boats exhibit various degrees of wetting and subsequent polycrystallinity. On the other hand, despite reduced wetting, material grown in carbon boats is the more strongly *n*-type. Typically, a crystal grown in a carbon boat yields an electron concentration of $1{\cdot}3 \times 10^{18}$/cm.^{3} and Hall mobility, $\mu_n = 2{,}500$ cm.^{2}/V./sec., compared with the usual 3×10^{18}/cm.^{3} and 5,000 cm.^{2}/V./sec. obtained for crystals grown in silica. It is worth adding that in all cases the observed mobility is less than that to be expected from the carrier concentration[1], implying a fair degree of compensation. There is, therefore, a considerable gain to be achieved by the removal of residual impurities.

Although the results above indicate that the presence of carbon increases the donor concentration in gallium arsenide, the absence of wetting suggests that this is not due to carbon being dissolved in the melt. It is suggested, therefore, that the prime effect of carbon is to bring about reduction of the silica envelope according to the equation:

$$SiO_2(s) + 2C(s) \rightleftharpoons Si(s) + 2CO(g) \qquad (1)$$

Spectrographic examination indicates that silicon is present in fair amounts in gallium arsenide grown in carbon boats.

At the melting point of gallium arsenide, the standard free energy change for reaction (1) is $\Delta G^\circ = 26{,}000$ cal.[2]. Using the relation:

$$\Delta G^\circ = -RT \log_e Kp = -2RT \log_e p_{CO}$$

where p_{CO} is partial pressure of carbon monoxide, we obtain $p_{CO} = 1{\cdot}3 \times 10^{-2}$ atmosphere. We can see, therefore, that starting with carbon and silica in a closed system, free silicon is produced until the pressure of carbon monoxide reaches the above value. In addition, the free silicon is able to dissolve in molten gallium arsenide to form a dilute solution; its activity is thereby reduced and the reaction can proceed further from left to right.

Since similar results are obtained for carbon as for carbonized silica boats, it seems that silicon must enter the melt from the vapour phase. The following reactions are reversible and provide mechanisms for the transport of carbon and silicon from one part of the system to another:

$$C(s) + CO_2(g) \rightleftharpoons 2CO(g) \qquad (2)$$

$$Si(s) + SiO_2(s) \rightleftharpoons 2SiO(g) \qquad (3)$$

At 1,511° K., the partial pressure of silicon monoxide is $9{\cdot}55 \times 10^{-4}$ atmosphere.

In practice, the equilibrium vapour pressure of carbon monoxide is not attained. It seems likely that since the partial pressure of arsenic in the system is high (0·9 atmosphere), the rate at which silicon enters the melt is mainly limited by gaseous diffusion and convection.

Carbon should be a satisfactory crucible material for gallium arsenide under conditions where it is unable to react with reducible oxides such as silica. Recent chemical analysis of gallium arsenide grown in contact with carbon has shown the carbon content to be less than $2{\cdot}7 \times 10^{17}$ atoms/cm.^{3}, which is the limit of detection of the method. One would expect the solubility of carbon in gallium arsenide to be comparable with that in germanium at the same temperature (about 10^{12} atoms/cm.^{3} at 1,511° K.).

This work is being carried out under Admiralty contract *CP.4D(2) 5298/58/60.2.*

J. R. KNIGHT

The Plessey Co., Ltd.,
Caswell Research Laboratories,
Towcester, Northants.

[1] Hilsum, C., *Proc. Phys. Soc.*, **76**, Part 3, 414 (1960).
[2] Richardson, F. D., and Jeffes, J. H. E., *J. Iron and Steel Inst.*, **160**, 261 (1948).

Methane Oxidation initiated by Electrical Discharge

AN apparatus for the mass-spectrometric study of free radicals occurring in gas-phase reactions has recently been completed in this Laboratory. While testing the equipment we have investigated the reactions in a methane–oxygen mixture, subsequent to electrical discharge in one of the gases.

The apparatus, which is illustrated in Fig. 1, is essentially similar to that of Foner and Hudson[1]. A flow of gas is maintained through a silica discharge tube, the discharge products being swept into the 'Pyrex' reaction vessel, where they may mix with another gas entering down a side tube. The mixing zone is sampled by a pinhole in platinum foil leading to the ion source of a Metropolitan-Vickers *M.S.2* mass spectrometer. The ion source was modified by the makers to provide a higher pumping speed, differential pumping from the filament region, and line-of-sight access from the pinhole leak to the ionization chamber.

The electrical discharges were maintained by a 200-watt radio transmitter, working at 13,560 kc./s., which supplied a coil wound around the discharge tube, 2 ft. above the sampling pinhole. Pressures of 500–750μ and flow-rates of 500–700 ml./sec. were used in this work.

The detectable products from a discharge in methane were mainly ethane and hydrogen, with some acetylene and ethylene; approximately one-third of the methane was removed, but the C_2 hydrocarbons detected could only account for 60 per cent of this. When oxygen was added (through the side tube) to the products of a discharge in methane the detectable products were scarcely affected; there was a slight decrease in the amount of ethane formed, and some water and carbon dioxide were detected, but 40 per cent of the carbon was still unaccounted for.

If the oxygen is submitted to the electrical discharge and the products mixed with undissociated

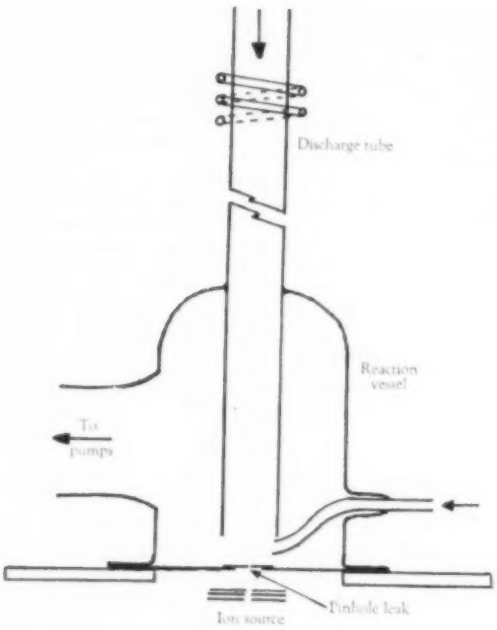


Fig. 1

methane, the detectable products of the reaction are very different. Within the limits of the present work there is a carbon balance, 80 per cent of that lost as methane appearing as ethane, and the remainder equally divided between ethylene and carbon dioxide; no acetylene is detectable. The remaining hydrogen appears mainly as water, only about 10 per cent being H_2.

A large residual peak exists at a mass/charge ratio of 17, its height being two and a half times that of the water peak at $m./e. = 18$. We are unable to explain this peak, except by assuming the presence of hydroxyl radicals.

Since we were not able to use low electron energies to confirm the presence of free radicals[2], the above conclusions must be regarded as tentative. Work is now in progress to use the low electron energy method, and also to coat the surface of the platinum foil so as to reduce the rate of recombination of radicals thereon; further results will be reported in due course.

We wish to thank Mr. G. Wilkinson for glass-blowing, and Dr. J. W. Linnett for the use of the mass spectrometer, which was provided by grants from the Department of Scientific and Industrial Research and Esso Research, Ltd. One of us (M. B.) is the holder of a Department of Scientific and Industrial Research maintenance grant, and the other (J. C.) is an Imperial Chemical Industries, Ltd., Research Fellow.

M. Barber
J. Cuthbert

Inorganic Chemistry Laboratory,
Oxford.

[1] Foner, S. N., and Hudson, R. L., *J. Chem. Phys.*, **23**, 1974 (1955).
[2] Cuthbert, J., *Quart. Rev.*, **13**, 215 (1959).

Internuclear Distances of Methyl and Methylene Radicals

The experimental determination of the geometry of the methyl and methylene radicals is very difficult[1,2]. Hence it may be of some interest to report estimates of the internuclear distances of the methyl and methylene radicals. Comparisons were made of several hydride radicals and molecules of the first row of the Periodic Table as shown in Table 1 and Fig. 1. The arrangement indicates regularity in the differences of the internuclear distances of these structures.

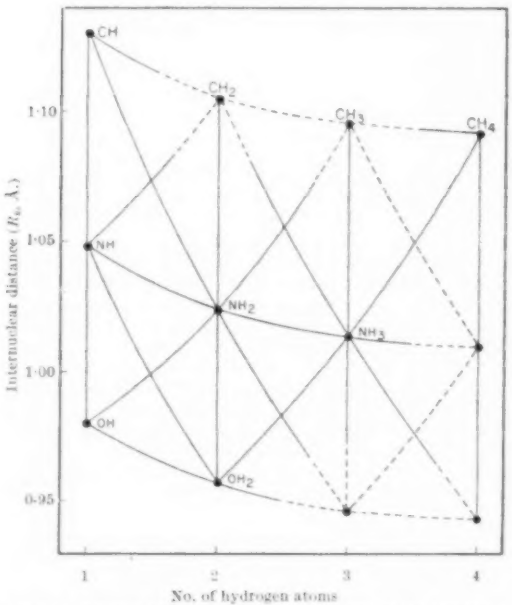


Fig. 1. Relation between internuclear distances of the hydrides of elements of the first row of the Periodic Table as a function of the number of hydrogen atoms

The internuclear distances of methyl and methylene radicals are estimated to be respectively 1·096 and 1·105 Å. It is interesting to point out the general utility of networks of the type shown in Fig. 1. A large grid of which Fig. 1 is a part has been used in another connexion[3]. A physically significant point of such a network must lie at the juncture of four lines as indicated in the diagram. The structures shown in Fig. 1 are both radicals and saturated molecules. Since the nitrogen hydrides fit into this simple scheme,

Table 1. Comparison of Internuclear Distances of First-Row Hydrides

	R_e		R_e		R_e		R_e
CH	1·130[a]	CH_2	1·105[b]	CH_3	1·096[b]	CH_4	1·092[f,g]
NH	1·048[a]	NH_2	1·024[c,d]	NH_3	1·014[e]		
	0·082		0·081		0·082		
NH	1·048[a]	NH_2	1·024[c,d]				
OH	0·980[a]	OH_2	1·957[d]				
	0·068		0·067				

[a] Cottrell, T. L., *The Strengths of Chemical Bonds* (Academic Press, Inc., New York, 1954). [b] Estimates. [c] Ref. 1. [d] Ramsay, D. A., *J. Chem. Phys.*, **25**, 188 (1956). [e] Herzberg, G., *Infra-red and Raman Spectra of Polyatomic Molecules* (D. A. Nostrand Co., Inc., New York, 1945). [f] Shepard, G. G., and Welsh, H. L., *J. Mol. Spectroscopy*, **1**, 277 (1957). [g] Kuchitsu, K., Bartell, L. S., and deNevi, K. J., Amer. Chem. Soc. New York Meeting (1960).

Table 2. GEOMETRY OF THE HYBRID METHYLENE RADICAL

CH or CD Å.	Fig. angle	I(CHD) $\times 10^{-40}$ gm. cm.^{2}	Deviation from y-axis
1·105	137° 20′	5·262	6° 50′
1·095	140°	5·252	6° 15′
1·071	147° 54′	5·230	4° 46′

it may be expected that the corresponding carbon hydrides should also be located within the same framework in similar manner.

From the rotational constants[2] $B''(CD_2) = 3·96$ and $B''(CHD) = 5·33$ cm.$^{-1}$, the principal moments of inertia of the CHD radical are found to be: $I(CD_2) = 7·084 \times 10^{-40}$ gm. $\times$ cm.^{2} and $I(CHD) = 5·247 \times 10^{-40}$ gm. $\times$ cm.^{2}. In the latter case, the figure axis inclines slightly from the y-axis of the co-ordinate system. The comparison shown in Table 2 indicates that neither the measured distance (1·071 Å.) nor the predicted value (1·105 Å.) is satisfactory. It can also be seen that a carbon–hydrogen distance of 1·095 Å. yields $I(CHD) = 5·252 \times 10^{-40}$ gm. $\times$ cm.^{2}, which checks the experimental value. However, the results rest on the assumption that the experimentally determined rotation constants are correct. Unless the two radicals under discussion show some extraordinary electron configurations, it is expected that the present prediction and final experiment must ultimately agree. No detailed calculations have been made for the methyl radical.

GEORGE GLOCKLER

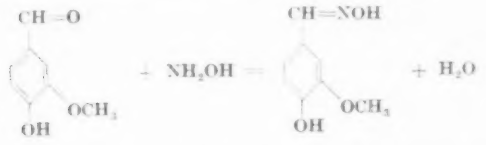
Department of Chemistry,
Duke University,
Durham,
North Carolina.

[1] Herzberg, G., *Proc. Chem. Soc., Lond.*, 116 (1959).
[2] Herzberg, G., *Nature*, **183**, 1801 (1959).
[3] Glockler, G., *Seventeenth Intern. Union Pure and App. Chem. Cong., Munich* (1959) (Butterworths, London, in the press); *J. Phys. Chem.*, **61**, 31 (1957).

Polarographic Determination of Vanillin

VARIOUS physico-chemical and chemical methods have been used for the determination of vanillin. Of the volumetric methods[1], the oxime method has been modified in many ways, whereby either the quantity of the hydrochloric acid set free in the reaction of hydroxylamine hydrochloride with vanillin, or the quantity of the unreacted hydroxylamine, is titrated visually or potentiometrically. Colorimetric methods are based on the slight reducing capacity of phenols[2], the polarographic methods[3] on the reduction of the aldehydic group of vanillin.

I have devised a new method for the determination of vanillin by utilizing the condensation of the aldehydic group with hydroxylamine with formation of the oxime, according to the following scheme:



The resulting oxime is polarographically active. The condensation of the aldehydic group proceeds quantitatively and the resulting oxime is reduced at more positive potentials. The sensitivity of the method is twice that of the direct polarographic determination. The condensation as well as the reduction of vanillin oxime proceed best in a phosphate buffer of pH 5·9. Under these conditions, the height of the oxime wave is precisely double that of vanillin before condensation (Fig. 1).

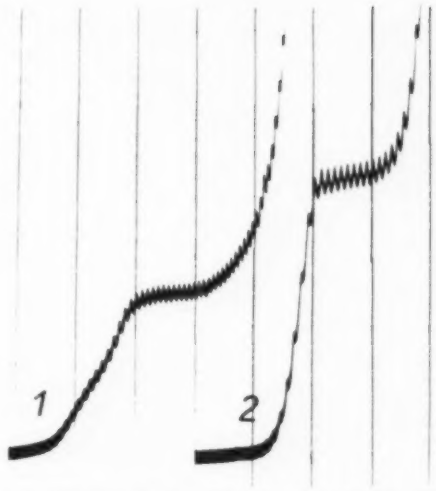


Fig. 1. Condensation of vanillin with hydroxylamine. Curve 1: 5 ml. 0·1 M ammonium chloride + 5 ml. 1×10^{-2} M vanillin solution, from −1·30 V. Curve 2: 4 ml. phosphate buffer, pH 5·9 + 5 ml. 1×10^{-3} M vanillin solution + 1 ml. 1 M hydroxylamine hydrochloride, from −0·78 V. Saturated mercurous sulphate electrode, sensitivity 1:30, 195 mV./absc.

In phosphate buffer of pH 5·9, vanillin is reduced at a half-wave potential of −0·93 V. (sat. calomel electrode) in a single well-developed four-electron wave. The dependence of the height of the oxime wave is a linear function of the concentration of vanillin. The wave shows a diffuse character, is easy to read and suitable for analytical use.

A detailed account of the reaction conditions and of the utilization of the method for the analysis of vanillin, both in the pure state and in foods, will be described elsewhere.

JIŘÍ DAVÍDEK

Department of Chemistry and
Control of Food,
Institute of Chemical Technology,
Prague.

[1] Sharp, L. K., *Analyst*, **76**, 215 (1951). Böhme, H., and Winkler, O., *Z. Lebensm.-Untersuch. u Forsch.*, **99**, 22 (1954). Martin, M. L., Kelly, K. L., and Green, M. V., *J. Amer. Pharm. Assoc., Sci. Ed.*, **35**, 220 (1940). Berka, A., and Zýka, J., *Československ. farm.*, **6**, 335 (1956); *Chem. listy*, **50**, 131 (1956).
[2] Wilson, J. B., *J. Assoc. Offic. Agric. Chemists*, **25**, 155 (1942). Englis, D. T., and Manchester, N., *Anal. Chem.*, **21**, 591 (1949).
[3] Winkel, A., and Proske, G., *Ber. deut. chem. Ges.*, **69**, 1917 (1936). Brdička, R., *Čas. čes. lékárnictva, Věd. příl.*, **58**, 37 (1956).

Spectrophotometric Determination of the Electron Affinities of Some Diatomic Molecules

THE purpose of this communication is to present a calculation of the electron affinities of some molecules from charge transfer spectra. Mulliken's[1] theory for a charge-transfer process leads to the expression:

$$h\nu_{max.} = I_D - E_A - \Delta \qquad (1)$$

where $h\nu_{max.}$ is the energy corresponding to the most probable electronic transition, I_D and E_A are the vertical ionization potential of the electron

donor and the vertical electron affinity of the electron acceptor. Δ represents the stabilization energy, relative to the ground-state, of the excited state in the nuclear configuration corresponding to the ground-state. This relation has been confirmed for some series of various donors with one acceptor[2,3] and for series of a particular donor with various acceptors[4].

By using spectroscopic data for charge transfer from one electron donor to various electron acceptors the electron affinities of these acceptors may be evaluated, provided that one absolute value of E_A is accurately known. It is assumed that the value of Δ is independent of the nature of the electron acceptor[4]. Thus, equation (1) leads to the relation:

$$h\nu_{max.}^{(1)} - h\nu_{max.}^{(2)} = E_{A_2} - E_{A_1} \qquad (2)$$

The magnitude of the vertical electron affinities of molecular halogens have not yet been established. These data were calculated by using the recent experimental results for the absorption spectra of iodine atom and aromatic hydrocarbon complexes[5] (Table 1).

Table 1. Electron Affinities of Molecular Halogen Compounds from Charge Transfer Spectra of Benzene Complexes

Electron acceptor A	$\lambda_{max.}$	$h\nu_{max.}$	$E_I - E_A$	E_A	$E_X - D_{X_2}$ (refs. 8 and 9)	E_A (previous estimation)
I	495 (ref. 5)	57·8	0	74·6 ± 1·5 (ref. 8)		
I_2	297 (ref. 6)	96·3	38·5	36	40 ± 1·5	41·5 (ref. 1)
Br_2	292 (ref. 7)	98·0	40·2	34	35·6 ± 1·5	
Cl_2	278 (ref. 7)	102·9	45·1	30	30·7 ± 1·5	≤39 (ref. 8)
ICl	287 (ref. 7)	99·6	41·8	33		

Wave-lengths given in mμ. Energetic data in kcal.

The lower limit for the equilibrium values of the electron affinities $E^e_{X_2}$ of the homonuclear molecules X_2 can be obtained from the relation:

$$E^e_{X_2} \geqslant E_X - D_{X_2} \qquad (3)$$

where D_{X_2} is the dissociation energy of the molecule. The values obtained for the vertical electron affinities of the halogens are smaller than the lower limits for $E^e_{X_2}$. As the stabilization energy of the excited state of the atomic iodine complex may be slightly higher compared with the corresponding state of the molecular iodine complex, the data of Table 1 present the lower limits for the vertical electron affinities of the halogen molecules. The vertical electron affinity of I_2 is expected to be lower than the corresponding equilibrium value[10]. However, our results indicate that in the benzene–iodine complex the repulsive part of I_2^- curve does not cross the I_2 curve at its minimum, as was indicated by the results of the dissociative attachments of the electrons in free iodine[10].

The same method was applied for the evaluation of the electron affinities of oxygen and of nitric oxide. Ultra-violet absorption spectra of oxygen in aromatic and aliphatic hydrocarbons[11–13] and of nitric oxide in alcohols[14] were observed. The continuous bands were assigned to charge transfer spectra[12,13], the oxygen and nitric oxide molecules acting as electron acceptors. The band onset energy $h\nu_0$ (arbitrarily chosen for $\varepsilon = 10$ litre mole^{-1} cm.$^{-1}$) was used for the specification of the transition energy. It is assumed that the vibrational broadening is independent of the electron acceptor. This relation is quite well fulfilled for the series of the I_2 aromatic complexes. The energetic data for oxygen and nitric oxide complexes are presented in Table 2.

Using the value of E_{I_2} we obtain $E_{O_2} = 17 \pm 4$ kcal. and $E_{NO} = 20 \pm 4$ kcal.

A recent theoretical estimation of the equilibrium electron affinity of oxygen[15] leads to a much lower value of 3·5 kcal. However, the result obtained for E_{O_2} from charge transfer spectra is in agreement with the equilibrium electron affinity of oxygen estimated from thermochemical data[8].

Electron attachment experiments in nitric oxide indicate that the electron affinity of this molecule is positive[8].

J. Jortner
U. Sokolov

Department of Physical Chemistry,
The Hebrew University,
Jerusalem.

[1] Mulliken, R. S., *J. Amer. Chem. Soc.*, **74**, 811 (1952).
[2] McConnel, H., Ham, H., and Platt, J. S., *J. Chem. Phys.*, **21**, 66 (1953).
[3] Hastings, S. H., Franklin, J. L., Schiller, J. C., and Matsen, F. A., *J. Amer. Chem. Soc.*, **75**, 2900 (1953).
[4] Forster, R., *Nature*, **181**, 337 (1958).
[5] Strong, R. L., Rand, S. J., and Britt, J. A., *J. Amer. Chem. Soc.*, **82**, 5053 (1960).
[6] Benesi, H. A., and Hildebrand, J. H., *J. Amer. Chem. Soc.*, **71**, 2703 (1949).
[7] Andrews, L. J., and Keefer, R. M., *J. Amer. Chem. Soc.*, **72**, 4677, 5170 (1950); **73**, 462 (1951).
[8] Pritchard, O. H., *Chem. Rev.*, **52**, 529 (1953).
[9] Herzberg, G., *Spectra of Diatomic Molecules* (Van Nostrand, New York, 1950).
[10] Biondi, M. A., and Fox, R. E., *Phys. Rev.*, **109**, 2012 (1958).
[11] Evans, D. F., *J. Chem. Soc.*, 345 (1953); 1351, 3885 (1957).
[12] Munck, A. U., and Scott, J. F., *Nature*, **177**, 587 (1956).
[13] Tsubomura, H., and Mulliken, R. S., *J. Amer. Chem. Soc.*, **82**, 5966 (1960).
[14] Jortner, J., and Sokolov, U., *J. Phys. Chem.* (in the press).
[15] de Maine, P. A. D., *J. Chem. Phys.*, **26**, 1192 (1957).
[16] Mulliken, R. S., *Phys. Rev.*, **115**, 1225 (1959).

BIOCHEMISTRY

Structure of Collagen

A triple helical structure for collagen with two systematic hydrogen bonds for every three residues was put forward from this laboratory in 1955 [1]. This structure was criticized by Rich and Crick[2] on the basis of a few short interatomic contacts occurring in it; they suggested that only structures with one hydrogen bond for every three residues will be free of bad contacts. Recently, we have examined the whole question carefully, and it has been found that

Table 2. Determination of the Electron Affinities of Oxygen and Nitric Oxide

D \ A	I_2 λ_0	I_2 $h\nu_0$	O_2 λ_0	O_2 $h\nu_0$	NO λ_0	NO $h\nu_0$	$E_{I_2} - E_{O_2}$	$E_{NO} - E_{O_2}$
Benzene	380 (ref. 6)	76	301 (ref. 14)	95			19	
Cyclohexane	280 (ref. 3)	102	242 (ref. 12)	118			16	
Methanol	300 (ref. 15)	95	248 (ref. 14)	115·3	252 (ref. 14)	112	20	3
Ethanol	300 (ref. 15)	95	251 (ref. 14)	114			21	

Wave-lengths given in mμ. Energetic data in kcal.

it is possible to build up a two-bonded structure (two hydrogen bonds for three residues) while retaining all contacts within permissible values. This has been possible mainly because a study of the observed interatomic contacts in various reported organic structures showed that contact distances actually occur which are much shorter than those mentioned by Rich and Crick[2], namely, C . . . C = 3·6 – 4·0 Å. and C . . . O = 3·2 – 3·4 Å. In fact, if Rich and Crick's criteria were adopted, some of the accepted structures like the α-helix will become unacceptable. Secondly, the study of the relation between the NH . . . O hydrogen bond distance and the infra-red frequency showed that the observed frequency (Ramachandran, G. N., Sasisekharan, V., and Thathachari, Y. T., unpublished work) in collagen, which is higher than that observed in other proteins, should correspond to a value of the order of 3·0 Å. The actual parameters of the minor helix of the collagen structure have also been re-determined. These gave a value of 2·95 Å. for the residue height and 3·28, rather than 3·33 (10/3), for the number of residues per turn. As a consequence, the twist for three residues in the triple helical structure should be 30° rather than 36°.

On the basis of these results, a satisfactory two-bonded structure has been worked out, and its co-ordinates are given in Table 1. The two hydrogen bonds which are formed, namely, $N_1H_1 \ldots O_2$ and $N_3H_3 \ldots O_3$, are of the same type as in the earlier structure proposed by Ramachandran and Kartha[1]. They are of the order of 3·00–3·05 Å. and the hydrogen-bond angles are less than 30°. The primary bond distances, bond angles and the deviation from planarity of the amide group are all well within the ranges observed in organic structures. Denoting the three chains by *A*, *B* and *C*, the only short contacts which occur are: (1) $O_2(A) \ldots O_3(A) = 2{\cdot}73$ Å.; (2) $C_1(B) \ldots O_2(A) = 2{\cdot}90$ Å.; (3) $C_4(A) \ldots O_2(B) = 3{\cdot}10$ Å.; (4) $C_4(A) \ldots O_3(B) = 3{\cdot}03$ Å.; and (5) $C_1(A) \ldots C_1(B) = 3{\cdot}50$ Å. The structure is thus seen to be satisfactory in every respect.

Table 1. Atomic Co-ordinates of the Atoms in One Set of Three Residues of the Proposed Structure of Collagen

The cylindrical polar co-ordinates given are with respect to the axis of the major helix

Atom	r (Å.)	Degrees	z (Å.)
C_1	1·15	0·0	0·00
C_2	2·27	12·0	1·00
O_2	3·26	−3·6	1·15
N_3	2·43	38·8	1·70
H_3	2·15	63·1	1·71
C_3	3·52	35·4	2·72
C_4	2·93	23·0	3·06
O_3	1·75	17·5	4·16
N_1	3·79	15·8	4·82
H_1	4·78	18·1	4·70
C_1	3·47	−2·0	6·00
C_2	2·50	18·7	6·86
O_2	2·68	45·5	6·50
N_3	1·95	−1·8	7·87
H_3	2·29	−24·4	8·04
C_4	1·15	30·0	8·85

The two-bonded structure is found to be highly specific and is satisfactory only for a coiled-coil structure with a twist close to 30° for three residues, and is definitely unsatisfactory for twists of 10° and 50°. It is also satisfactory only for a residue-height close to 3·00 Å. Thus, it is possible to explain stereochemically why collagen occurs with the particular structure actually found and why the parameters are the same for collagen obtained from widely different sources. The inextensibility of the collagen structure can also be explained on the basis of the steric hindrance produced by the proline and hydroxyproline residues.

Although, when the sequence gly-pro-hypro occurs, two bonds cannot occur systematically, the above structure can be slightly modified locally to incorporate this sequence. The detailed co-ordinates for such a modified structure have also been worked out.

Finally, it may be mentioned that the calculated Fourier transform of the new structure is in good agreement with observation, and its expected infra-red dichroism is also consistent with the observations.

Thus we would expect that most of the residues in the regular collagen structure would take up a two-bonded configuration, which is highly specific. It should, however, be mentioned that other types of linkages such as ester linkages and gamma-peptide linkages have been reported for collagen, but the number of these is so small that the main structure is not likely to be affected by these.

We wish to thank Messrs. Y. T. Thathachari, B. R. Lakshmanan, and C. Ramakrishnan, who also collaborated in this project. The detailed results are to be published elsewhere.

G. N. Ramachandran
V. Sasisekharan

Department of Physics,
University of Madras,
Madras 25.

[1] Ramachandran, G. N., and Kartha, G., *Nature*, **176**, 593 (1955); *Proc. Ind. Acad. Sci.*, A, **42**, 215 (1955).
[2] Rich, A., and Crick, F. H. C., *Nature*, **176**, 915 (1955).

Effect of Temperature on the Concentration of Free Radicals in Melanins from *Allium cepa*

In a previous communication we reported the presence of free radicals in the seeds of the onion *Allium cepa*[1]. Further investigations have shown that these free radicals are attributable to the melanins present in the black seed-coats.

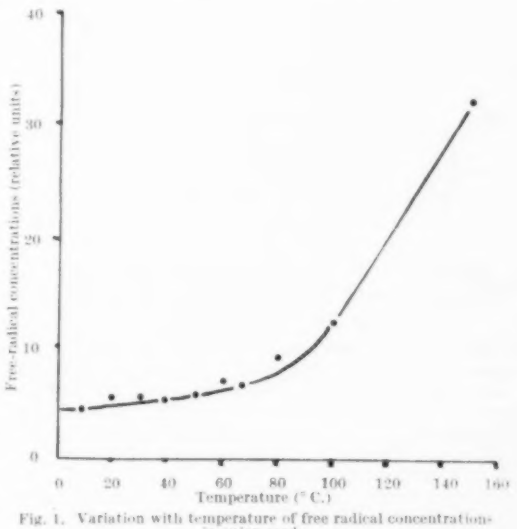


Fig. 1. Variation with temperature of free radical concentrations in onion seeds

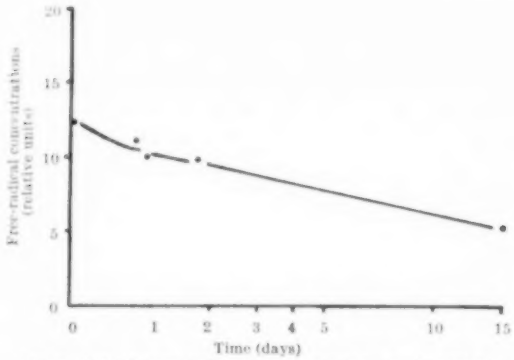


Fig. 2. Rate of decay in liquid oxygen (seeds heated to 100° C.)

Batches of 10 similar seeds were kept at a specified temperature for 15 min. and then placed in the liquid oxygen-surrounded cavity of a microwave spectrometer (125 kc./s. field modulation; *x*-band model, with automatic locking of klystron frequency to that of the cavity).

Fig. 1 shows the effect of temperature on the relative free-radical concentration, there being a marked increase in the seeds kept at 60° C. and above. The signal diminished in strength with time (the seeds being kept in liquid oxygen throughout the experiment). The fall was quite rapid over the first 3 hr. and slower thereafter. A similar effect of temperature on the signal strength was found to occur with seed-coats alone, or with melanin extracted from seeds by refluxing with concentrated potassium hydroxide. Melanins extracted from such widely different sources as *Calliphora* adults, *Rana* tadpoles, human hair and dark-coated seeds of *Dianthus barbatus*, *Delphinium* sp. and *Aesculus hippocastanum* gave results essentially similar to those described for onion seeds. Barley, marrow and French beans seeds without melanin in their seed coats gave no appreciable signal. Ingram, Allen and Mason[2] have described the presence of unpaired electrons in melanin extracted from *Sepia* ink and *Calliphora* pupæ.

M. L. Edwards
G. A. Kerkut
K. A. Munday
K. Leach
Department of Physiology and Biochemistry,
Department of Electronics,
University of Southampton.

[1] Edwards, M., Kerkut, G. A., Munday, K. A., Ingram, D. J., Saxena, M. C., and Leach, K., *Nature*, **184**, 1402 (1959).
[2] Mason, H. S., Ingram, D. J. E., and Allen, B., *Archiv. Biochem. Biophys.*, **86**, 225 (1960).

Adenosine Triphosphate- and Coenzyme *A*-dependent Decarboxylation of Oxalate by Extracts of Peas

Despite the wide distribution of oxalic acid in plants, and its high concentration in certain tissues[1], very little is known of its metabolism. Investigations with whole plants indicate that the acid is either metabolically inert[2,3] or metabolized slowly to glycollic acid[4]. Work with cell-free extracts, on the other hand, has demonstrated that the enzyme oxalate oxidase is widely distributed in higher plants. This enzyme has been shown to be associated with the 'particulate fraction' of sugar beet leaves[5,6] and roots[7].

The following report provides evidence for the presence, in extracts of germinating pea cotyledons, of an enzyme system which catalyses an adenosine triphosphate (ATP)- and coenzyme *A*-dependent conversion of oxalate to formate and carbon dioxide. The enzyme system is associated with the supernatant fraction obtained after centrifugation of a homogenate at 10,000*g* for 30 min., and does not require oxygen for activity.

Pea seeds (*Pisum sativum*, var. Telephone) were germinated in moist peat moss for five days. The cotyledons were homogenized with twice their weight of a solution containing 0·45 *M* sucrose, 0·2 *M tris* buffer of *p*H 7·2, and 5×10^{-4} *M* 2,3-dimercapto-1-propanol. The homogenate was squeezed through cheese cloth, the filtrate centrifuged at 1,200*g* for 7 min., and the supernatant so obtained centrifuged at 10,000*g* for 30 min. This crude supernatant was used as a source of the enzyme system. To demonstrate co-factor requirements, the crude supernatant was adjusted to *p*H 6·0 with 1 *M* acetic acid and centrifuged at 10,000*g* for 10 min. The clear supernatant solution was brought to *p*H 7·2 with 1 *M* potassium hydroxide, and dialysed for 3 hr. against 0·01 *M tris* buffer at *p*H 7·2. All operations were carried out at 0–3° C.

Table 1 shows the co-factor requirements for the decarboxylation of oxalate-1,2-^{14}C. The reaction was carried out in a conventional Warburg vessel, $^{14}CO_2$ being absorbed by 0·2 ml. 20 per cent potassium hydroxide in the centre well. After 30 min. incubation at 30° C., the reaction was stopped by tipping saturated potassium bisulphate from the side arm. Carbon-14 labelled carbon dioxide was precipitated as barium carbonate and the counts/min. determined with a Geiger–Müller tube. The results demonstrate an absolute requirement for ATP and coenzyme *A*. Omission of glutathione or magnesium ions causes a significant decrease in the rate of decarboxylation. Omission of phosphate causes a slight stimulation in the rate, while omission of thiamine pyrophosphate has little effect. By treatment of the enzyme system with 'Deacidite *FF*' in the chloride form, it is possible to demonstrate a stimulation in the rate of decarboxylation by the addition of thiamine pyrophosphate.

Table 1. Co-factor Requirements for the Decarboxylation of Oxalate-1,2-^{14}C

Components	$^{14}CO_2$ Counts/min.
Complete	1,012
Minus ATP	8
,, coenzyme *A*	7
,, glutathione	888
,, thiamine pyrophosphate	929
,, magnesium chloride	570
,, phosphate	1,255

The complete reaction mixture contained 1 μmole oxalate-1,2-^{14}C (12,200 counts/min.); 0·5 ml. enzyme (approx. 5 mgm. protein); 100 μmoles phosphate buffer *p*H 7·2; 5 μmoles glutathione; 0·1 μmole thiamine pyrophosphate; 0·1 μmole coenzyme *A*; 5 μmoles magnesium chloride; 5 μmoles ATP. Final volume 2·0 ml., *p*H 7·2

The stoichiometry of the reaction was demonstrated by incubating 1·14 μmoles of oxalate-^{14}C (100,000 counts/min.) with the enzyme system under the conditions shown in Fig. 1. At fixed times the reaction was stopped and $^{14}CO_2$ was determined as described here. Each reaction mixture was then extracted continuously with ether for approximately 20 hr., the ether extract so obtained evaporated to a small volume under a flow of ammonia gas, and the concentrated extract made up to a known volume. An aliquot of each of the extracts was chromatographed in 95 per cent ethanol/concentrated ammonia, 100:1 (v/v)[8]. A radio-autograph of the chromatogram

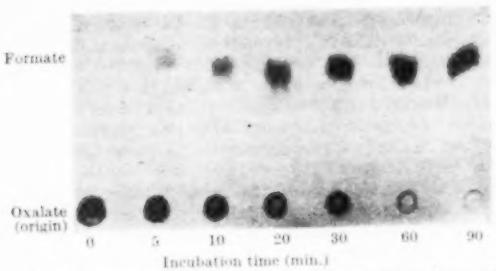


Fig. 1. Formation of formate-^{14}C during decarboxylation of oxalate-^{14}C. To each reaction vessel was added 1·14 μmoles oxalate-1,2-^{14}C (100,000 counts/min.); 1·0 ml. crude supernatant (approx. 27 mgm. protein); 5 μmoles glutathione; 0·1 μmole thiamine pyrophosphate; 0·1 μmole coenzyme *A*; 5 μmoles magnesium chloride; 10 μmoles ATP; 0·2 ml. 20 per cent potassium hydroxide in the centre well of a conventional Warburg vessel. Final volume 2·0 ml., *p*H 7·2. Temperature, 30° C.

(shown in Fig. 1) illustrates that the decarboxylation of oxalate-^{14}C is accompanied by the formation of a radioactive compound migrating ahead of oxalate-^{14}C. This compound was identified as formate-^{14}C by (*a*) two-dimensional co-chromatography with authentic formate, using 95 per cent ethanol/concentrated ammonia, 100:1 (v/v)[8], in the first dimension (R_F, 0·37), and absolute ethanol, 16 per cent ethylamine, 4:1 (v/v)[9], in the second dimension (R_F, 0·65); (*b*) steam volatility under acid conditions; (*c*) degradation to $^{14}CO_2$ by mercuric acetate[10].

Aliquots of the above extracts were assayed for formate-^{14}C and oxalate-^{14}C. Formate-^{14}C was first estimated by degradation to $^{14}CO_2$ by mercuric acetate. Oxalate-^{14}C was then estimated by degradation to $^{14}CO_2$ by ceric sulphate[11]. This procedure was found to give satisfactory quantitative recoveries using mixtures of authentic oxalate-^{14}C and formate-^{14}C. The results shown in Table 2 demonstrate that the decarboxylation of each mole of oxalate-^{14}C results in the formation of one mole of formate-^{14}C and one mole of $^{14}CO_2$.

Table 2. Stoichiometry of Oxalate Decarboxylation

Incubation time (min.)	Oxalate-1,2-^{14}C decarboxylated (μmoles)	Formate-^{14}C formed (μmoles)	$^{14}CO_2$ formed (μmoles)
0	0·00	0·02*	0·00
5	0·14	0·12	0·10
10	0·25	0·28	0·29
20	0·58	0·55	0·57
30	0·73	0·71	0·70
60	1·09	1·11	0·96
90	1·11	0·97	1·05

Conditions were the same as those described for Fig. 1. All samples were counted as barium carbonate. Each figure represents the mean of two determinations. The maximum deviation from the mean was ± 0·04 μmole.

* Separate experiments showed that up to 2 per cent of oxalate-^{14}C was consistently degraded to carbon-14 labelled carbon dioxide by mercuric acetate. The error is not known exactly for each estimation, but in every case represents a potential error less than the maximum deviation of ± 0·04 μmole.

It has not been possible to determine the stoichiometry of ATP in the reaction, since the enzyme system is quite crude. Coenzyme *A* is required only in catalytic quantities.

On the basis of the above evidence, the following scheme for decarboxylation of oxalate is suggested:

$$\text{Oxalate} + \text{coenzyme } A \xrightarrow{Mg,^2ATP} \text{oxalyl coenzyme } A$$

$$\text{Oxalyl coenzyme } A \longrightarrow CO_2 + \text{formyl coenzyme } A$$

$$\text{Formyl coenzyme } A \longrightarrow \text{formate} + \text{coenzyme } A$$

The reaction sequence is similar to that demonstrated by Jakoby *et al.*[12] for extracts of *Pseudomonas* grown on oxalate, and by Quayle *et al.*[13] for *P. oxalaticus* extracts. However, in both these systems oxalate was not activated directly, but required catalytic quantities of acetate[12] or succinate[13]. Treatment of the pea enzyme system with 'Deacidite *FF*' in the fluoride form failed to reveal a requirement for either acetate or succinate.

At present it is difficult to suggest a physiological role for this enzyme system in plants. The participation of ATP and coenzyme *A* suggests that the reaction may have some significance in the energetics of intermediary metabolism.

John Giovanelli*
Noel F. Tobin*

Plant Physiology Unit,
Department of Botany,
University of Sydney.

* Officers of the Division of Food Preservation, Commonwealth Scientific and Industrial Research Organization, Homebush, New South Wales.

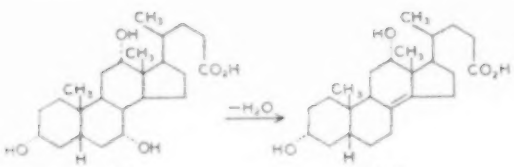
[1] Thimann, K. V., and Bonner, Jun., W. D., *Ann. Rev. Plant Physiol.*, **1**, 75 (1950).
[2] Vickery, H. B., and Abrahams, M. D., *J. Biol. Chem.*, **186**, 411 (1950).
[3] Cromble, W. M. L., *J. Exp. Bot.*, **5**, 173 (1954).
[4] Zbinovsky, V., and Burris, R. H., *Plant Physiol.*, **27**, 240 (1952).
[5] Arnon, D. I., and Whatley, F. R., *Physiol. Plant.*, **7**, 602 (1954).
[6] Finkle, B. J., and Arnon, D. I., *Physiol. Plant.*, **7**, 614 (1954).
[7] Meeuse, B. J. D., and Campbell, J. M., *Plant Physiol.*, **34**, 583 (1959).
[8] Kennedy, E. P., and Barker, H. A., *Anal. Chem.*, **23**, 1033 (1951).
[9] Long, A. G., Quayle, J. R., and Stedman, R. J., *J. Chem. Soc.*, 2197 (1951).
[10] Piric, N. W., *Biochem. J.*, **40**, 100 (1946).
[11] Vogel, A. I., *Quantitative Inorganic Analysis*, 378 (London, 1945).
[12] Jakoby, W. B., Ohmura, E. K., and Hayaishi, O., *J. Biol. Chem.*, **222**, 435 (1956).
[13] Quayle, J. R., Keech, D. B., and Taylor, G. A., *Biochem. J.*, **76**, 3 P (1960).

Carcinogenic Activity of Apocholic Acid

The production of cancer by bile acids is a topic of far-reaching interest, because of the natural occurrence and biosynthesis of these substances in the body and of their molecular structure, which places them in the biologically essential family of steroids. In view of this, the two main bile acids, namely, cholic acid and deoxycholic acid, have often been tested for carcinogenicity, but results have so far been either negative or controversial. Thus, while both Ghiron[1], and Cook *et al.*[2], were able to produce sarcomas in mice by subcutaneous injection of deoxycholic acid, Shear *et al.* recorded negative results with both cholic and deoxycholic acid and attributed the sarcomas described in the literature to the possible influence of the solvent used[3]; more recently, Klein also reported negative results using the intramuscular route[4]. It was, therefore, evident that if these acids were carcinogenic, their activity was weak in degree and not constantly reproducible.

This communication reports experiments made with apocholic acid (II), a product of mild dehydration of cholic acid (I), and the results indicate a definite carcinogenic activity for this compound.

Forty-two 3-month-old male mice of strain *XVII nc/Z* (Radium Institute) were given subcutaneous injections in the right flank (10 times with 10-day intervals between each injection) of 0·5 mgm. of apocholic acid dissolved in 0·2 c.c. sterile neutralized olive oil. Fourteen mice which died between the 120th and 217th day following the start of our



(I) (II)

experiment showed no tumour at the site of injection. The first sarcoma to be observed *in situ* occurred on the 204th day, and the animal died on the 227th day; three other mice developed sarcomas on the 230th, 241st, and 370th day, respectively.

Spontaneous sarcomas of the soft parts have never been observed in our strain of mice; nor could the excipient be held responsible for the production of the tumours: every year since 1955 a control group of some 40–60 mice are given 10 injections of 0·2 c.c. of the oil referred to above, and in similar conditions, and out of a total of 350 animals thus treated (120 of which survived over 500 days and 66 over 700 days) none has ever shown a tumour at the site of injection.

It is worth mentioning that both deoxycholic and apocholic acid are powerful complexing and enolizing agents, giving stable addition-compounds ('choleic acids') with numerous organic molecules[5]. The present work adds experimental evidence to the proposition that certain steroids with an appropriate molecular structure are able to produce tumours *in situ*[6]; it also lends support to the theory which postulates an enolization of proteins through van der Waals forces as an early step in certain mechanisms of chemical carcinogenesis[7].

We thank the National Cancer Institute, U.S. Public Health Service, for a grant, and Dr. E. Mosettig for a sample of pure apocholic acid.

A. Lacassagne
N. P. Buu-Hoï
F. Zajdela

Radium Institute,
University of Paris,
26 rue d'Ulm,
Paris V^e.

[1] Ghiron, V., *Proc. Third Internat. Cancer Congress*, 116 (1939).
[2] Cook, J. W., Kennaway, E. L., and Kennaway, N. M., *Nature*, **145**, 627 (1940). Badger, G. M., Cook, J. W., Hewett, C. L., Kennaway, E. L., Kennaway, N. M., Martin, R. H., and Robinson, A. M., *Proc. Roy. Soc.*, B, **139**, 439 (1940).
[3] Shear, M. J., *Amer. J. Cancer*, **33**, 499 (1938). Shear, M. J., Leiter, J., and Perrault, A., *J. Nat. Cancer Inst.*, **2**, 99 (1941).
[4] Klein, M., *J. Nat. Cancer Inst.*, **13**, 333 (1952).
[5] Fieser, L. F., and Fieser, M., *Natural Products related to Phenanthrene*, third ed., 115 (Reinhold Pub. Corp., New York, 1949).
[6] Lacassagne, A., *C.R. Soc. Biol.*, **132**, 365 (1939). Lacassagne, A., and Raynaud, A., *ibid.*, **132**, 431 (1939).
[7] Buu-Hoï, N. P., *Acta Unio Internat. Contra Cancrum*, **7**, 68 (1950).

Interaction of Proteins and Nucleotides in Buffered Aqueous Solutions

A number of reports have appeared in the literature on the binding of organic ions by proteins. Klotz and Luborsky[1] have discussed the influence of various solvents on the binding of such ions and the nature of the complexes which are formed. Kakuliya[2], studying the interaction of proteins with electrolytes, noted a decreased rate of specific conductivity and an increased *p*H when adenosine triphosphate (ATP) was added to a protein solution. Tonomura and Morita[3] observed the binding of pyrophosphate by myosin *A* and myosin *B*.

During the preparation of solutions containing ATP and albumin, Katz (personal communication) noted the formation of a precipitate. Since the solutions were not well buffered, we assumed that the precipitate was due simply to the formation of an insoluble un-ionized salt similar to protein precipitates formed by the action of trichloroacetic or phosphotungstic acid on aqueous solutions of proteins.

We have investigated this precipitation of nucleotides and proteins under rigorously controlled conditions of *p*H and of nucleotide and protein concentration and wish to report the results of our preliminary experiments.

In our first experiment the precipitation of albumin by ATP was investigated. All reactions were carried out in 7·0 ml. of McIlwain buffer at the *p*H's and concentrations shown in Table 1. All mixtures were centrifuged at 2,500 r.p.m. The supernatants were analysed for protein by a modification of the biuret reaction[4] and for ATP by measuring the optical density at 260 mμ in a Beckman *DU* spectrophotometer.

Table 1. Precipitation of Albumin by ATP

*p*H	Albumin (mgm.)	ATP (mgm.)	Albumin precipitated (mgm.)	ATP precipitated (mgm.)
2·2	4·0	21·2	4·0	9·7
	4·0	42·4	4·0	9·8
	4·0	84·8	4·0	9·8
3·4	4·0	21·2	4·0	7·7
	4·0	42·4	4·0	8·7
	4·0	84·8	4·0	6·6
4·6	4·0	21·2	0·25	0
	4·0	42·4	1·5	2·6
	4·0	84·8	4·0	5·3
5·6	4·0	21·2	0·25	0·2
	4·0	42·4	0·50	0
6·8	4·0	21·2	0·20	0
	4·0	42·4	0·40	0·4

It may be seen from Table 1 that there is complete precipitation of albumin at *p*H's below the isoelectric point of the protein and virtually no precipitation at *p*H's above this point.

Similar investigations were carried out using lysozyme, hæmoglobin, and human globulins. All these proteins were found to interact with ATP when the *p*H was on the acid side of the isoelectric point of the protein, but not when it was on the alkaline side. This could also be demonstrated when ATP was replaced by triphosphates of other purine or pyrimidine ribosides, but not when the corresponding diphosphates or monophosphates were used. We are at present trying to establish the quantitative nature of these reactions.

In another series of investigations the behaviour of the precipitate was examined. The precipitate formed by ATP and albumin was centrifuged and redissolved in distilled water. It was then lyophilized and dissolved in 0·05 ionic strength veronal buffer, *p*H 8·6. Paper electrophoresis of this solution yielded a single spot, the mobility of which was the same as that of the original albumin from which the precipitate was formed.

Similar results were obtained when albumin was replaced with hæmoglobin, lysozyme, and human globulins. In the case of lysozyme the enzymatic activity was found to be unaltered when the precipitate was redissolved.

The ability of ATP to react with serum proteins was also examined. To 0·5 ml. of human serum (dialysed against isotonic saline, *p*H 4·6) was added a solution of ATP buffered at *p*H 4·6. The precipitate

was obtained by centrifuging and redissolved in isotonic saline at an alkaline *p*H. Paper electrophoresis of this solution yielded spots with mobilities equal to those of human globulins, but no spots with the mobility of albumin. Paper electrophoresis of the supernatant of the original precipitate resulted in a single spot which migrated with human albumin at *p*H 8·6 and *p*H 7·4.

Selective precipitation has been of limited value as a preparative tool because of possible alterations of the proteins, both those precipitated and those remaining in solution. However, our results indicate that little, if any, alterations occur when ATP is used as the precipitating agent. This may have some limited application in the separation of proteins. Furthermore, it is felt that this reaction may have a bearing on the transport and storage of high-energy phosphate compounds.

This work was supported in part by a gift from Mr. and Mrs. Winston S. Cowgill in memory of Charles A. Christenson.

Joseph R. Debro
Melvin Lee

Department of Preventive Medicine,
University of California School of Medicine,
San Francisco.

[1] Klotz, I. M., and Luborsky, S. W., *J. Amer. Chem. Soc.*, **81**, 5119 (1957).
[2] Kakuliya, M. E., *Biofizika*, **4**, 32 (1959).
[3] Tonomura, Y., Matsomiya, H., Morita, F., and Kilagana, S., *Conf. Chem. Muscular Contraction, Tokyo*, 22 (1958).
[4] Kingsley, G. R., *J. Lab. and Clin. Med.*, **27**, 840 (1942).

Electrophoretic Mobility of Cultured Mesodermal Tissue Cells

Ambrose *et al.*[1] have shown that individual tumour cells from hamster kidney possess a significantly greater electrophoretic mobility than normal homologous kidney cells. Later, Purdom *et al.*[2] obtained a correlation between the development of a mouse sarcoma and the progressive increase in the negative electrophoretic mobility of individual cells obtained from this sarcoma at various stages of its development. As the tumour cell acquired more malignant properties, evinced by the formation of early metastases, the negative electrophoretic mobility of individual cells was observed to have increased.

Recently, Ben-Or *et al.*[3] observed that the electrophoretic mobility of individual cells from adult rat liver during regeneration was appreciably greater than that of homologous non-regenerating liver cells. They suggested that the raised electrophoretic mobility of the former was an expression of growth in general rather than of malignancy in particular.

We have found that mouse fibroblasts cultured by conventional methods from embryonic tissue, mouse subcutaneous fibroblasts[4] strain *L*, clone 929 (obtained from Mrs. A. A. Newton, Department of Biochemistry, The University, Cambridge) and fibroblasts cultured from the hearts of adult mice show reproducible microelectrophoretic mobilities, which are the same for fibroblast cultures freed from the glass either mechanically (policemen) or enzymically (trypsin).

The embryonic fibroblasts possess a mobility significantly greater than the adult fibroblasts, with the *L*-strain fibroblasts exhibiting an intermediate electrophoretic mobility (Table 1).

All tissue cells were prepared for microelectrophoresis by the procedure used for human erythrocytes[5]. The electrophoretic mobility measurements

Table 1. Mobilities of Various Cells in 0·145 *M* Sodium Chloride : 2×10^{-3} *M* Sodium Bicarbonate, at 37·0 ± 0·1°

System	*p*H	Mobility (μsec.$^{-1}$ V.$^{-1}$ cm.)
Embryonic mouse fibroblasts	6·0–8·0	−0·97 ± 0·05
Adult mouse fibroblasts	6·0–8·0	−0·82 ± 0·05
L-strain mouse fibroblasts	6·0–8·0	−0·88 ± 0·05

on the cells were made in a cylindrical microelectrophoresis chamber at 37·0 ± 0·1° as described previously[6]. A mobility determination was based on the migration of about one hundred individual cells. No appreciable divergence in the electrophoretic mobility of individual batches of cells has been observed from one culture to another. Human erythrocytes washed in the same 0·145 *M* aqueous sodium chloride system were used as a reference standard[5].

The *L*-strain fibroblasts, originally derived from Earle's 20-methylcholanthrene-treated strain *L* which produced sarcomata on injection into *C3H* strain mice, can probably be considered to be malignant. However, sub-lines of the *L*-strain may differ from the original in a number of ways, as a result of transformations during the long period since the initial cloning[7]. Any direct comparisons between the *L*-strain and the embryonic and adult fibroblasts (cultured only for about 100 hr.) may be misleading. The *L*-strain, however, does exhibit an electrophoretic mobility greater than that of the adult fibroblasts in keeping with the observations in ref. 1. Though any electrophoretic mobility measurements made on tissue cells after washing and removal from a natural or a culture medium must be viewed with caution in relation to the behaviour *in vivo*, it is probably permissible to compare the mobility of the adult and embryonic fibroblasts cultured *in vitro* (Table 1).

The higher electrophoretic mobilities of the embryonic fibroblasts as compared with the adult fibroblasts support the views expressed in ref. 3. A raised electrophoretic mobility is therefore probably associated with growth in general and thus it is not simply the higher net negative electrokinetic charge of malignant cells which is the significant factor in their invasiveness.

D. H. Heard
G. V. F. Seaman*
I. Simon-Reuss

Department of Radiotherapeutics,
Cambridge.

* Beit Memorial Research Fellow.

[1] Ambrose, E. J., James, A. M., and Lowick, J. H. B., *Nature*, **177**, 576 (1956).
[2] Purdom, I., Ambrose, E. J., and Klein, G., *Nature*, **181**, 1586 (1958).
[3] Ben-Or, S., Eisenberg, S., and Doljanski, F., *Nature*, **188**, 1200 (1960).
[4] Sanford, K. K., Earle, W. R., and Likely, G. D., *J. Nat. Cancer Inst.*, **9**, 229 (1948).
[5] Heard, D. H., and Seaman, G. V. F., *J. Gen. Physiol.*, **43**, 635 (1960).
[6] Bangham, A. D., Flemans, R., Heard, D. H., and Seaman, G. V. F., *Nature*, **182**, 642 (1958).
[7] Fedoroff, S., and Cook, B., *J. Exp. Med.*, **109**, 615 (1959).

Identification of 20β-Hydroxy-pregn-4-ene-3-one in Luteal Tissue from Pregnant Whales

Using biological methods of assay, several authors have reported gestogen activity in extracts of whale corpora lutea[1–4]. Prelog and Meister[5] were the first to isolate progesterone from this source by a chemical method and reported amounts of 3 mgm. per 100 gm. tissue. In addition to progesterone the biologically

inactive 5α-pregnane-3β-ol-20-one was also found. These two substances seem to be the only steroids isolated from the reproductive organs of the whale.

Since either 20α- or 20β-hydroxy-pregn-4-ene-3-one, or both, have been shown recently to be naturally occurring gestogens in several mammalian species, it seemed of interest to make a search for these compounds in the whale as well.

In this investigation a combination of chromatographic and spectrophotometric methods was applied to extracts of luteal tissue from pregnant fin-whales (*Balaenoptera physalus* L.). The tissues were collected in the Antarctic and kept frozen until processed.

Portions of tissue were homogenized and extracted with ethanol/ethyl ether (3 : 1). After removal of fatty material by repeated precipitations in cold 70 per cent methanol, the methanolic solution was shaken with three times its volume of petroleum ether (boiling point 40–60° C.) and collected. The petroleum ether was then extracted with five additional volumes of 70 per cent methanol, the pooled extracts evaporated, the residue taken up in a small volume of absolute methanol and chromatographed on paper. Evaporations were made at reduced pressure below 60° C. For chromatography the ligroin–80 per cent methanol system of Zander and Simmer[6] (system 1), and the heptane–formamide system of Zaffaroni (system 2) were used.

Three compounds were easily detected by contact photography of chromatograms using light of 253 mμ. Their ultra-violet absorption spectra in methanol with a distinct maximum at 240 mμ and the positive soda fluorescence reactions indicated the presence of the Δ^4-3-keto-grouping in the steroid molecule. After rechromatography in system 1, one compound moved like progesterone. It was present in large amounts, and its infra-red absorption spectrum was shown to be identical with that of progesterone. The second compound showed chromatographic behaviour like 20β-hydroxy-pregn-4-ene-3-one in both system 1 and 2, both as the free and acetylated compound. More material was processed, and the substance was isolated in quantities sufficient for registration of the infra-red absorption spectrum, which was found to be identical with that of the authentic 20β-hydroxy-pregn-4-ene-3-one.

The third substance was chromatographically similar to 20α-hydroxy-pregn-4-ene-3-one in both the free and acetylated form in system 1. However, in system 2 it moved faster than this substance, both free and acetylated. Moreover, it showed a negative reaction to the iodine test, which is considered to be rather specific for the 20α-grouping. The identity of this substance remains to be established.

From the observations reported, it seems safe to conclude that both progesterone as well as 20β-hydroxy-pregn-4-ene-3-one are naturally occurring gestogens in the whale. This corresponds to those found in the horse[7] and the cow[8], while in man both the 20α- and 20β-hydroxy compounds are present in addition to progesterone[9]. In rat ovarian tissue 20α-hydroxy-pregn-4-ene-3-one and progesterone have recently been found to be reversibly interrelated[10]. Species variations in stereospecific enzymes in gestogen metabolism therefore seem to occur. The observations reported here for the whale add to our knowledge about such variations.

We are indebted to Prof. Å. Jonsgård, University of Oslo, for his aid in obtaining material from whales, to Prof. W. Klyne, London, for generous gifts of reference compounds, and to S. Veige, chemical engineer, AB Leo, Halsingborg, Sweden, for recording and interpretation of infra-red absorption spectra.

John Kristoffersen
Torleiv Lunaas
Weibert Velle

Department of Reproductive Physiology and Pathology,
Veterinary College of Norway, Oslo.

[1] Jacobsen, A. P., *Tidsskrift f. den norske Laegeforening*, 262 (1935).
[2] Jacobsen, A. P., *Nature*, **136**, 1029 (1935).
[3] Callow, R. K., Laurie, A. H., and Parkes, A. S., *Chem. and Indust.*, **54**, 1025 (1935).
[4] Bomskov, C., Wassiollek, B., and Doht, W., *Klin. Wschr.*, **19**, 392 (1940).
[5] Prelog, V., and Meister, P., *Helv. Chim. Acta*, **32**, 2435 (1949).
[6] Zander, J., and Simmer, H., *Klin. Wschr.*, **32**, 529 (1954).
[7] Short, R. V., *J. Endocrinol.*, **15**, 1 (1957).
[8] Gorski, J., thesis, Washington (1958).
[9] Zander, J., Forbes, T. R., von Münstermann, A. M., and Neher, R., *J. Clin. Endocrinol. and Metabol.*, **18**, 337 (1958).
[10] Wiest, W. G., *J. Biol. Chem.*, **234**, 3115 (1959).

Antibodies blocking Neutralization of Penicillinase by the Homologous Antiserum

Immunization of rabbits with purified exopenicillinase of *Bacillus cereus* results in the appearance of antibodies which neutralize approximately 90 per cent of the activity of the enzyme[1,2]. The present communication describes the preparation and some of the properties of neutralization-blocking antibodies, evoked by injection of penicillinase-producing cells. Immune serum containing neutralization blocking antibodies will be referred to as 'blocking antiserum'.

The strains of *B. cereus* used in this work were the wild-strain 569, which forms penicillinase following induction with penicillin, and the mutant-strain 569/*H*, derived from strain 569, which forms penicillinase constitutively.

Neutralizing antiserum was prepared by immunizing rabbits with a highly purified preparation of exopenicillinase produced by strain 569/*H* of *B. cereus*[3]. 20 mgm. of the enzyme were administered with Freund's adjuvant in 3 intramuscular injections at 10-day intervals.

Blocking antiserum was prepared by immunizing rabbits with intact cells of *B. cereus* 569/*H*. The cells were collected from a 12-hr. old broth culture, washed with, and resuspended in, physiological saline. The immunization consisted of 7 subcutaneous injections over a period of 40 days. Each dose contained 100 mgm. bacterial dry weight.

Absorption of antibodies was carried out by mixing equal volumes of sera and packed bacterial cells and incubating for 2 hr. at 37° C. The mixture was kept for 20 hr. at 4° C. before cells were removed by centrifuging.

The effect of the blocking antiserum on the interaction of penicillinase with the neutralizing antiserum was assayed in the following way. 0·2 ml. aliquots of a purified penicillinase preparation (575 units/ml.) were incubated (30 min. at 28° C.) with 0·2 ml. of the appropriate dilutions of the blocking antiserum. A quantity of neutralizing antiserum in excess of that required for maximal neutralization (1,000 neutralization units in 0·2 ml.) was added and the mixture incubated for another 30 min. Normal rabbit serum replaced blocking antiserum, neutralizing antiserum or both in the respective control tubes. The activity of penicillinase was assayed by the iodometric method[4].

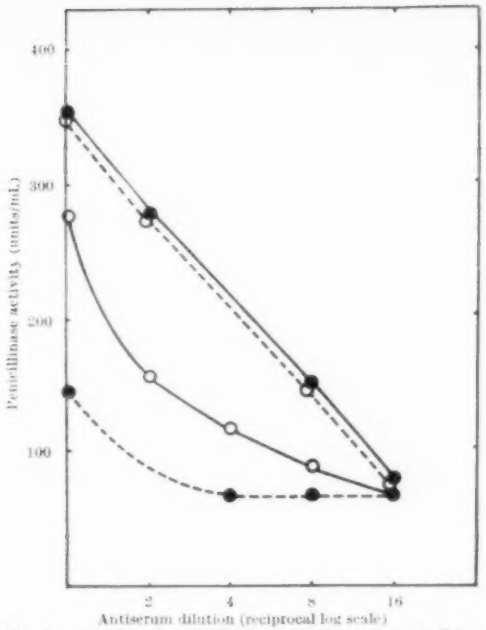


Fig. 1. Activity of penicillinase incubated with neutralizing serum, following exposure to serial dilutions of 'blocking antiserum'. The 'blocking antiserum' was treated as follows: ●- - - -●, Absorbed with constitutive cells; ○——○, absorbed with induced cells; ○ - - - ○, absorbed with non-induced cells; ●——●, untreated

The results, presented in Fig. 1, are expressed as residual enzyme activity following incubation with varying dilutions of the blocking antiserum and excess of neutralizing antiserum. Also shown in Fig. 1 is the effect of absorption of the blocking antiserum by the homologous (569/*H*) cell suspension, and by both induced (that is, penicillinase forming) and non-induced cells of the parent strain 569.

It will be noted that the undiluted non-absorbed blocking antiserum interferes strongly with inhibition of penicillinase by the neutralizing antiserum. The inhibition decreases as the blocking antiserum is diluted. Blocking antibodies are removed largely by absorption with the homologous cells, and, to a lesser extent, by absorption with induced 569 cells. Absorption with non-induced 569 cells has no effect on the blocking titre of the antiserum.

The blocking antiserum agglutinates cells of the constitutive (569/*H*) stram and, to a lesser degree, induced cells of the adaptive strain 569. The agglutinating titre for non-induced cells is very low. Thus the susceptibility to agglutination by the blocking antiserum appears to be related to the level of penicillinase formed by the cell. A similar correlation has been found in cross-absorption experiments. Absorption of the antiserum with constitutive cells resulted in complete removal of agglutinins, whereas absorption with non-induced cells had no effect on the titre of agglutination of constitutive cells. Induction of penicillinase imparted to the adaptive cells a limited ability to absorb agglutinins. The results are summarized in Table 1.

The close correlation between the blocking and agglutinating properties of the antiserum suggests that both activities may be due to a single species of antibody, directed to cell-bound penicillinase.

Table 1. Agglutinating Titre of the 'Blocking Antiserum'

Serum absorbed with	Cell suspension agglutinated		
	Constitutive	Induced	Non-induced
(*a*) Constitutive cells	0	0	0
(*b*) Induced cells	1 : 640	1 : 40	0
(*c*) Non-induced cells	1 : 1,280	1 : 80	0
(*d*) Not absorbed	1 : 1,280	1 : 80	1 : 20

A difference in the immunological response to cell-bound and to extracellular penicillinase was to be expected on the basis of established antigenic differences between the two states of the enzyme[4,5].

Quite apart from the structural aspects of the bound and free forms of bacterial penicillinase, the present observations may bear on the problem of *in vivo* resistance to penicillin. The acquired resistance to penicillin of clinically important micro-organisms depends in most cases on their ability to form penicillinase[6]. Formation of penicillinase-neutralizing antibodies could thus be regarded as a specific component of the acquired defence mechanism of the host. Modification of the host response, along the lines described, might have a distinct survival value for the infecting agent.

This work was supported by a grant from the U.S. Public Health Service (*E* 3097).

Nathan Citri
Gill Strejan

Department of Bacteriology,
Hebrew University–Hadassah Medical School,
Jerusalem.

[1] Housewright, R. D., and Henry, R. J., *J. Bacteriol.*, **58**, 621 (1949).
[2] Pollock, M. R., *J. Gen. Microbiol.*, **14**, 90 (1956).
[3] Citri, N., Garber, N., and Sela, M., *J. Biol. Chem.*, **235**, 3454 (1960).
[4] Citri, N., *Biochim. Biophys. Acta*, **27**, 277 (1958).
[5] Pollock, M. R., *J. Gen. Microbiol.*, **15**, 154 (1956).
[6] Barber, M., in *Ciba Foundation Symp. on Drug Resistance in Micro-organisms*, edit. by Wolstenholme, G. E. W., and O'Connor, C. M., 262 (J. and A. Churchill, Ltd., London, 1957).

PHYSIOLOGY

Effect of Temperature on the Retinal Slow Potential of the Horseshoe Crab

In a previous paper[1] we indicated that the retinal slow potential, a generator potential, of the horseshoe crab (*Tachypleus tridentatus*) decreased in its amplitude as the time in darkness before illumination is reduced, even if stimuli of equal intensity and duration were applied. This depressive effect of the short time-interval is compatible with the 'depression'[2] or 'refractoriness'[3] of the receptor potential of the Pacinian corpuscles. It was found that the grade of 'depression' as well as the amplitude of the retinal slow potential is affected by changes in temperature, though the resting potential seems to be little influenced.

The retinal slow potentials were recorded intracellularly from single ommatidia of the horseshoe crab by the same procedure as that described by another author[4]. The temperature of the bathing solution could be varied between 6° C. and 23° C. by controlling the inflow of the cold or warm oxygenated physiological solution for the horseshoe crab[5] or sea-water which was stored in a cylinder, and was measured by employing a thermocouple which was placed by the preparation.

The records illustrated in Fig. 1 are responses obtained after 60 (column *A*) and 15 (column *B*) sec. in darkness at various temperatures. As shown in

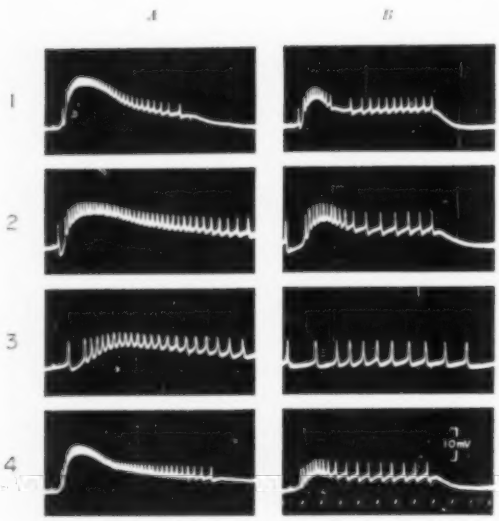


Fig. 1. Effect of temperature on the action potentials arising within a single ommatidium of the horseshoe crab. Records in column *A* and *B* were obtained by the same stimuli after 60 and 15 sec. in darkness at various temperatures. From the top records downwards, 12, 9, 6 and 12° C. The onset and turn-off of illumination are indicated as pips. Note the reverse effect of temperature on the amplitude of the slow potential and the spike potential. Time, 0·1 sec.

Fig. 1, differences in the shape of the slow potential due to its time in darkness before illumination were also found at different temperatures. In addition, the separation of the initial maximal and the decreased, sustained depolarization, which is usually clearer in the responses obtained by illumination of high intensity and after a shorter time in darkness or at high temperature, became indistinct at low temperature (records 3 in column *A* and *B*) as the result of the prolongation of the falling phase of the initial maximal depolarization. In most other experiments, flashes which are short enough to obtain simple responses without any additional decreased depolarization were applied to make the measurement of the falling phase of the slow potential easier.

The temperature coefficient of the amplitude of the maximal depolarization of the slow potential was much larger than that reported in the propagated action potential of nerve[6] and muscle[7] fibres. Its Q_{10} was positive and ranged from about 3 to 5 in the responses obtained after 60 sec. in darkness. It should be mentioned that the temperature coefficient of the duration of the rising phase was larger than that of the falling phase, being negative. On the other hand, the temperature coefficient of the amplitude of the spike potential generated by the retinal slow potential was negative, as it is in the giant axon of the squid[8].

The records of the bottom row of Fig. 1 were taken after the temperature had been raised once more to that of the top records. The amplitudes of the slow potentials were both smaller than their initial figures. This after-effect of cooling was often observed under our experimental conditions in which temperature was lowered at the rate of about 0·5° C./min., and raised at about 1° C./min. This seems not to be due to the depolarization of the membrane potential during the temperature run, since it could appear without any significant change in the resting potential in most cases. Thus the after-effect can be explained by saying that when the temperature is changed it takes time for the new functional level to establish itself.

These effects of temperature on the slow potential indicate that some chemical processes are probably involved in the generation of the retinal slow potential, one of them being suggested by Fuortes[8]. A detailed report on the effect of temperature on the electrical activity of the sensory cell in the lateral eye of the horseshoe crab is being prepared for publication.

R. Kikuchi
K. Naito
S. Minagawa

Department of Physiology,
Tokyo Women's Medical College,
Shinjuku-ku, Tokyo.

[1] Kikuchi, R., and Tazawa, M., in *Electrical Activity of Single Cells* (Igakushoin, Tokyo, 1960).
[2] Gray, J. A. B., and Sato, M., *J. Physiol.*, **122**, 610 (1953).
[3] Loewenstein, W. R., and Altamirano-Orrego, R. J., *J. Gen. Physiol.*, **41**, 805 (1958).
[4] Tomita, T., *Jap. J. Physiol.*, **6**, 327 (1956).
[5] Kikuchi, R., and Tanaka, I., *Annot. Zool. Japon.*, **30**, 177 (1957).
[6] Hodgkin, A. L., and Katz, B., *J. Physiol.*, **109** (1949).
[7] Macfarlane, W. V., and Meares, J. D., *J. Physiol.*, **142**, 97 (1958).
[8] Fuortes, M. G. F., *J. Physiol.*, **148**, 14 (1959).

Binding of Calcium Ions by the Aorta

Previous work[1] has shown that the aorta has an inherent ability to bind calcium ions *in vitro*. This binding in turn had a marked influence on the stability of emulsions, causing precipitation. The distribution and solubility characteristics of the primary substance suggested that collagen was responsible for the calcium binding, although other possibilities were recognized. Because of the importance attributed to binding of calcium ions by the aorta in plaque formation[1], further work is reported here to add to the information concerning the identity of the binding agent(s). This was accomplished by noting the effect of various enzymes and extractive procedures on the aortic binding of calcium chloride labelled with calcium-45 which could be followed autoradiographically.

All experiments were conducted with human thoracic aortas of adult males. These were prepared as described previously[1], and used in the form of pieces 6 cm.[2] in order to conserve material. Following decalcification with ethylenediaminetetraacetate at *p*H 7·2 in the cold and subsequent washing and extraction with acetone–petroleum ether[1], the strips were incubated overnight with the appropriate enzyme at 37° C. at optional *p*H. They were then washed free of enzyme, and incubated overnight with 3–4 μc. labelled calcium chloride in sealed vials. After washing and drying, the strips were exposed to dental film for 17 hr. within a plastic cassette. Conditions for radioautography were strictly controlled to permit comparison with control strips which were not enzymatically treated. All experiments were repeated at least twice and in duplicate. Summarized in Table 1 are the results of various treatments on the calcium-binding of the aorta. In all cases the physical appearance of the aorta strip remained intact following the experimental procedure.

These results indicate that several factors may be responsible for calcium-binding by the aorta. These are protein in nature as made evident by the fact that

Table 1

Treatment	Effect on calcium binding
(1) Hyaluronidase[2], bovine testes, 300 U.S.P. units/mgm. per 15 ml. saline-acetate, *p*H 6·0	None
(2) Elastase[3], 100 units/5 mgm., 15 ml. saline, *p*H 8·0	None
(3) Collagenase, 10 mgm./15 ml. distilled water, *p*H 7·2	Very slight reduction
(4) Alkaline phosphatase, intestinal, 180,000 Bodansky units/15 ml. saline, *p*H 8·4	Marked reduction
(5) Trypsin, twice crystallized, 10 mgm./15 ml. distilled water, *p*H 8·0	Complete elimination
(6) Extraction of soluble proteins with 0·25 *M* glucose[4]	None
(7) Extraction of chondroitin sulphate with 30 per cent KCl–1 per cent K_2CO_3[5, 6]	Marked enhancement

they are completely eliminated by trypsin digestion. The present evidence would indicate that the factors are not hyaluronic acid, elastin or collagen, but probably an insoluble protein-phospholipid complex. Phospholipids, in particular the sphingomyelins, have been reported to increase in atherosclerotic aortas[7,8]. The extraction with potassium chloride–potassium carbonate appears to remove an inhibitor of the calcium binding which has the properties of a chondroitin sulphate.

I. Gordon Fels

Radioisotope Service,
Veterans Administration Hospital,
Hines, Illinois.

[1] Fels, I. G., *Circ. Res.*, **7**, 693 (1959).
[2] Meyer, K., *Physiol. Rev.*, **27**, 335 (1947).
[3] Sacher, L. A., Winter, K. K., and Sicher, W., *Proc. Soc. Exp. Biol. Med.*, **90**, 323 (1955).
[4] Valdiguie, P., Douste-Blazy, L., and Lavabre, T., *C.R. Acad. Sci. Paris*, **122**, 1590 (1958).
[5] Einbinder, J., and Schubert, M., *J. Biol. Chem.*, **185**, 725 (1950).
[6] Partridge, S. M., and Davis, H. F., *Biochem. J.*, **68**, 298 (1958).
[7] Buck, R. C., and Rossiter, R. J., *Arch. Path.*, **51**, 224 (1951).
[8] Shore, M. L., Zilversmit, D. B., and Ackerman, R. F., *Amer. J. Physiol.*, **181**, 527 (1955).

Effects of Certain Androgenic Steroids on the Increase of Endometrial Carbonic Anhydrase caused by Progesterone

It has previously been demonstrated by Lutwak-Mann[1] that, as a result of treatment of oestrogen-primed rabbits with methyltestosterone, an appreciable increase in endometrial carbonic anhydrase occurred, and that when methyltestosterone and progesterone were given simultaneously, methyltestosterone appeared to prevent the activating effect of progesterone on the endometrial enzyme. The present investigation dealt with the question of how other androgenic steroids affect the endometrial carbonic anhydrase response to progesterone. The following steroids were tested: methyltestosterone, androstenedione, androstanolone, Δ^5-androsten-3β, 17β-diol and stigmasterol.

All experiments were performed on immature albino rabbits, weighing approximately 1·5 kgm. at the beginning of the experiments. Following Clauberg's method[2], the rabbits were injected subcutaneously once daily with 5 μgm. of oestradiol for six days. After this period, progesterone and androgen were given simultaneously in five divided doses at daily intervals by subcutaneous injection into the neck of the animal. The standard dose of progesterone was 2·0 mgm. and the androgen doses varied as indicated in Table 1. On the second day after the last injection, the rabbits were killed by breaking the neck and cutting the carotid artery. The uteri were isolated and rinsed with cold saline. The endometrium was dissected and homogenized with cold distilled water. The homogenate was centrifuged and the supernatant was used for the determination of enzyme activity. The enzyme activity of the extract was estimated colorimetrically by modifying the Philpot and Philpot method[3], one enzyme unit being defined as $(T_0 - T)/T$, where 'T_0' is the reaction time without enzyme and T is the same with enzyme.

As can be seen in Table 1, a dose of 2 mgm. of progesterone caused a marked increase in the activity of endometrial carbonic anhydrase. However, when various doses of androgen were given with 2 mgm. of progesterone, the combined effect of the two steroids on the enzyme activation was rather lower than that due to 2 mgm. of progesterone alone. In a dose of 0·02 mgm., considerable lowering of endometrial enzyme activity was demonstrated in methyltestosterone, androstenedione and androstanolone. There was significant difference between the endometrial enzymes with and without androgen. Percentage inhibition of carbonic anhydrase was 42 by methyltestosterone, 52 by androstenedione and 49 by androstanolone. However, 0·02 mgm. of Δ^5-androsten-3β,17β-diol and stigmasterol were not so pronounced as the other androgens, an inhibition of 34 per cent each being observed. A total of 0·2 mgm. proved exceedingly effective for the inhibition of the effect of 2 mgm. of progesterone, causing a 47 per cent inhibition by Δ^5-androsten-3β,17β-diol and a 42 per cent by stigmasterol.

The androgens used caused a significant fall in the increased enzyme activity produced by progesterone. It seems that the anti-progestational ability is practically the same for methyltestosterone, androstenedione and androstanolone, but somewhat weaker than the others in Δ^5-androsten-3β,17β-diol and stigmasterol.

We wish to thank Dr. W. O. Nelson, of the Population Council, Inc., and Dr. G. Pincus, of the Worcester Foundation for Experimental Biology, for supporting this work. This investigation was carried

Table 1. Effects of Androgenic Steroids on Endometrial Carbonic Anhydrase Increase caused by Progesterone

Group	Series of hormone	No. of rabbits	Dose of progesterone (mgm./animal)	Dose of androgen (mgm./animal)	Carbonic anhydrase content (enzyme units/gm. wet tissue)
a	Control	10	sesame oil		24 ± 3
b	Progesterone	11	2·0		557 ± 36
c	Progesterone + methyltestosterone	6 5 5	2·0 2·0 2·0	0·2 0·02 0·002	480 ± 44* 333 ± 5 447 ± 36*
d	Progesterone + androstenedione	6 5 4	2·0 2·0 2·0	2·0 0·2 0·02	385 ± 24 367 ± 31 280 ± 22
e	Progesterone + androstanolone	5 4 6 5	2·0 2·0 2·0 2·0	2·0 0·2 0·02 0·002	458 ± 37* 378 ± 32 294 ± 21 366 ± 44
f	Progesterone + Δ^5-androsten-3β,17β-diol	3 4 4	2·0 2·0 2·0	2·0 0·2 0·02	599 ± 34* 304 ± 35 375 ± 27
g	Progesterone + stigmasterol	5 3 5	2·0 2·0 2·0	2·0 0·2 0·02	494 ± 41* 332 ± 39 377 ± 68

* $P > 0·05$ compared with group *b*.

out with the support of a grant from the Population Council, Inc., New York.

KAZUKUNI YAMASHITA*
KEN-ICHI KUROUJI

Department of Physiology,
Nagasaki University School of Medicine,
Nagasaki, Japan.

* Present address: Worcester Foundation for Experimental Biology, Shrewsbury, Massachusetts.

[1] Lutwak-Mann, C., *J. Endocrinol.*, **13**, 26 (1955).
[2] Clauberg, C., *Zentr. Gynäkol.*, **54**, 2757 (1930).
[3] Philpot, F. J., and Philpot, J. St. L., *Biochem. J.*, **30**, 2191 (1936).

Effect of Allyl*iso*propylacetamide on Liver Metabolism

THE administration of allyl*iso*propylacetamide (AIA) causes porphobilinogenuria in rabbits[1], but it is not known whether this is caused by an increased synthesis of porphobilinogen (PBG) or a decreased utilization. PBG is synthesized in the liver via δ-aminolævulinic acid (ALA) from glycine and acetate or succinate and it seemed possible that a study of the effect of AIA on the metabolism of carbon-14-labelled glycine, acetate and succinate by rabbit liver might throw a light on the problem.

Four male rabbits (2·5–3·0 kgm.) each received 300 mgm. of AIA by stomach tube twice daily for 6 days. The urine from each animal then contained about 14 mgm./100 ml. of porphobilinogen (24 mgm./24 hr.) and 7·5 mgm./100 ml. of ALA (13 mgm./24 hr.). Four rabbits not treated with AIA were controls. The animals were killed, and chopped preparations[2] of the livers incubated with substrates labelled with carbon-14 as indicated in Table 1. The tissue was incubated for 3 hr. at 37° in air, killed and extracted with ethanol, and the ethanol-aqueous extracts chromatographed in two dimensions using phenol–water as the first solvent and *n*-butanol–propionic acid–water as the second. Radioactive substances on the chromatograms were located by radioautography and counted directly on the paper with an end-window counter[3]. The carbon-14 contained in each compound was expressed as a percentage of the total carbon-14 in the cell extract.

There was a decreased total incorporation of the isotope into the soluble intermediaries. Nevertheless, with labelled acetate and succinate as substrates considerably more carbon-14 was present in glutamic acid in the AIA-treated animals compared with the controls; this was also true for alanine when labelled succinate was used as substrate. When [2 : 3-^{14}C] succinic acid was the substrate, the radioactivity in glutamic acid and alanine was about twice as great in both groups of animals as with [1 : 4-^{14}C] succinate as substrate (Table 1). This is to be expected if these two amino-acids were derived from succinate via the tricarboxylic acid cycle and transamination. No other obvious differences in distribution of carbon-14 were seen between the tissues from AIA-treated and the control animals in the incorporation of carbon-14 into aspartic acid, glucose, proline, γ-aminobutyric acid, valine, lactic, malic and fumaric or citric acids. The lack of increased incorporation from labelled acetate and succinate into aspartate in the AIA-treated animals compared with the controls suggests that there was no increased passage of carbon atoms from the keto-acids into the corresponding amino-acids derived from them by transamination. The preferential incorporation of carbon-14 into the alanine and glutamic acid may indicate that there is an abnormality of the further metabolism of these amino-acids in the AIA-treated animals, but it seems unlikely that this is directly related to the mechanism responsible for the porphobilinogenuria.

It was impossible to interpret the experiments using [2-^{14}C] glycine because the material decomposed to a variable extent during the purification and chromatographic procedures.

We thank the Mental Health Research Fund for a personal grant to one of us (M. K.).

C. H. GRAY
MARGARET KELLY
V. MOSES

Department of Chemical Pathology,
King's College Hospital Medical School,
Denmark Hill,
London, S.E.5.

[1] Goldberg, A., and Rimington, C., *Proc. Roy. Soc.*, B., **143**, 257 (1955).
[2] Smith, M. J. H., and Moses, V., *Biochem. J.*, **76**, 579 (1960).

Table 1. TOTAL INCORPORATION AND DISTRIBUTION OF CARBON-14 IN ALANINE AND GLUTAMIC ACID

Group of animals	Control			AIA-treated		
Substrate	[2-^{14}C]acetate	[1 : 4-^{14}C]succinate	[2 : 3-^{14}C]succinate	[2-^{14}C]acetate	[1 : 4-^{14}C]succinate	[2 : 3-^{14}C]succinate
Glutamic acid	11·1 ± 2·0 (6·7–16·3)	0·19 ± 0·05 (0·12–0·31)	0·39 ± 0·10 (0·30–0·67)	20 ± 3·7 (13–27)	0·73 ± 0·17 (0·50–1·2)	1·5 ± 0·30 (1·1–2·4)
Alanine	4·0 ± 0·75 (1·7–5·1)	2·6 ± 0·44 (1·4–3·4)	4·2 ± 0·6 (2·4–5·0)	5·2 ± 0·67 (0–1·7)	4·6 ± 0·67 (2·8–5·8)	8·5 ± 2·0 (4·2–13)
Total carbon-14	95 ± 48 (35–240)	1,700 ± 280 (1,100–2,300)	1,600 ± 250 (900–2,000)	65 ± 9·2 (40–79)	1,500 ± 320 (990–2,400)	1,400 ± 270 (900–2,200)

Samples of rabbit liver (containing about 10 mgm. dry weight of tissue in a vol. of 0·25 ml.), derived from four control animals and from four animals treated with AIA, were incubated in air for 3 hr. at 37° with 5 μc. of either 1·01 μmoles [2-^{14}C]acetate, 0·46 μmole [1:4-^{14}C]succinate or 0·46 μmole [2 : 3-^{14}C]succinate. The total carbon-14 incorporated into the sum of the soluble metabolic intermediates is expressed as 10^{-3} × counts/min./25 mgm. dry wt. of tissue. The radioactivity found in glutamic acid and alanine is expressed as a percentage of the total carbon-14 in the sum of the soluble metabolites. All results are given as the mean of 4 observations ± S.E. (range).

Inhibition of Emotional Reactions by Phenothiazine Tranquillizers

PHENOTHIAZINE tranquillizers inhibit conditioned responses of various laboratory animals. Since this action can be demonstrated by means of a great variety of methods, it is generally considered to be characteristic of these compounds. Some tranquillizers also diminish 'emotional reactions'[1–4]; but these effects have not been studied so much, mainly due to a lack of simple and adequate methods. Thus, views are still divided whether depression of the emotional reaction is a primary effect or an effect secondary to the sedative action of such drugs[2–4]. Any new technical procedure which permits the study of the influence of a drug on emotional behaviour independent of its general depressive effect, therefore, appears interesting.

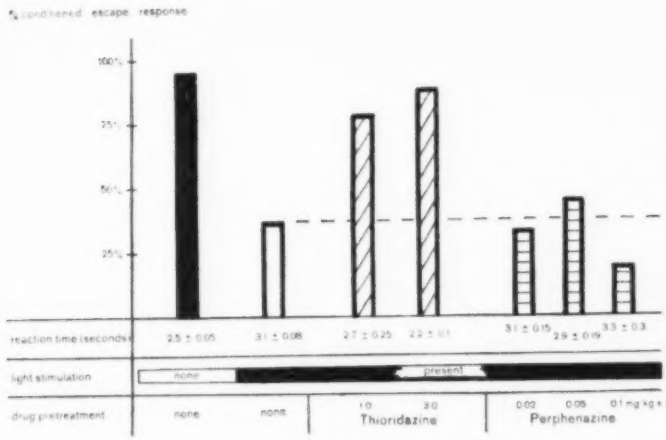


Fig. 1. An intense light stimulus prevents the normal course of a conditioned escape response in rats in a non-reinforced procedure. Thioridazine inhibits this disturbing influence. Perphenazine is ineffective in this respect, but depresses further the conditioned response

Based on frequent observations that novel stimuli which elicit an emotional reaction in rats regularly interfere with the correct performance of a conditioned response, the following test was devised: rats were trained to climb a vertical pole as soon as an acoustic signal (conditioned stimulus—tone of 500 c./s.) was sounded. The animals could thus avoid an electric shock delivered 5 sec. later through the grilled floor of the cage (conditioned escape response)[5]. Each rat was trained daily for 10 successive trials with a 1-min. interval between each trial. After an adequate training period, all rats performed the conditioned escape response correctly in 94 ± 1·1 per cent of all trials, the average reaction time being 2·4 ± 0·07 sec. During the subsequent trials, an intense light stimulus (100 W.) was applied 2 sec. prior to each acoustic signal. This stimulus terminated simultaneously with the acoustic signal either at escape or after 5 sec., that is, at the onset of the electric shock. The rats exposed to the light stimulus performed the conditioned escape response in only 63 ± 2·5 per cent of all trials with an average reaction time of 2·5 ± 0·08 sec. These results demonstrate that the light stimulus interferes partially with the conditioned escape response. Light stimulation elicited a higher degree of disturbance in a non-reinforced procedure in which no electric shock was applied, that is, conditioned escape response in only 37 ± 2·4 per cent of all trials within 3·1 ± 0·08 sec. (In control trials without light stimulation, the conditioned escape response was performed in 95 ± 0·9 per cent of all non-reinforced trials with an average reaction time of 2·5 ± 0·05 sec.)

In the circumstances, it appeared more suitable to study drug action on this disturbing influence by means of the non-reinforced procedure. In order to avoid any accommodation to the interfering light stimulus, this test was carried out only once a week, reinforced training procedure being followed on the other days. Each group alternately underwent the non-reinforced procedure alone and the non-reinforced procedure with prior light stimulation under drug therapy and saline. At least 20 trials in 10 rats were required to assess the action of one dose of drug. The compounds were administered subcutaneously 2 hr. before the test, controls receiving saline. Two phenothiazines were selected which were found in previous studies[4] to possess an opposite activity pattern: perphenazine and thioridazine. The results of these experiments are summarized in Fig. 1. Rats pretreated with thioridazine (1 and 3 mgm./kgm.) perform the conditioned escape response correctly despite the disturbing light stimulus (78 ± 7·2 per cent and 88 ± 1·9 per cent). Their reaction time is normalized or even slightly shorter than in rats not exposed to the light stimulus. Thioridazine, therefore, inhibits the disturbing influence of the light stimulus. Perphenazine, on the other hand, does not prevent the disturbing influence of the light stimulation; a minimal effect is noted with a low dose of 0·05 mgm./kgm. (45 ± 5·9 per cent), whereas higher doses (0·1 mgm./kgm.) further depress the conditioned escape response (19 ± 3·3 per cent).

It is generally assumed that an intense light stimulation elicits an emotional response in rats[6]; such emotional reactions (confusion, stupor, anxiety, etc.) can interfere with the normal operant behaviour of the animals[7] or—as shown in these experiments—with the performance of a conditioned response. The degree of depression of the motor behaviour serves as a measure of the extent of the emotional reaction. The finding that the thioridazine-treated rats perform the conditioned escape response correctly despite the disturbing light stimulus points to a primary action of this drug on the emotional response. This anti-emotive property is apparently not due to general sedation, as it is demonstrable in doses which do not inhibit the conditioned response. On the other hand, perphenazine does not inhibit the emotional reaction. However, this compound further inhibits, in relatively low doses (0·1 mgm./kgm.), the conditioned escape response.

These findings are in accord with those obtained in previous work[4,5] when it was found that thioridazine depresses selectively emotional defecation and has relatively little effect on the conditioned escape response in rats, whereas perphenazine inhibits predominantly the conditioned response and depresses emotional defecation only in higher doses. Apparently, the depression of emotional reactions on one hand, and inhibition of a conditioned escape response on the other, are, to a certain degree, two independent properties of the phenothiazine tranquillizers.

Max Taeschler
Aurelio Cerletti

Pharmacological Laboratories,
Sandoz, Ltd.,
Basle.

[1] Brady, J. V., *Ann. N.Y. Acad. Sci.*, **64**, 632 (1956).
[2] Hunt, H. F., *Ann. N.Y. Acad. Sci.*, **65**, 258 (1956).
[3] Ryall, R. W., *Nature*, **182**, 1606 (1958).
[4] Taeschler, M., and Cerletti, A., *Nature*, **184**, 823 (1959); *Münch. med. Wschr.*, **102**, 1000 (1960).
[5] Taeschler, M., Fanchamps, A., and Cerletti, A., *Psych. Neurol.* (Basle), **139**, 85 (1960).
[6] Keller, F. S., *Psychol. Rev.*, **4**, 235 (1941).
[7] Estes, W. K., and Skinner, B. F., *J. Exp. Psychol.*, **29**, 390 (1941)

Further Evidence for Phosphatidic Acid as the Sodium Carrier

We have presented evidence[1,2] before that phosphatidic acid acts as the Na^+ carrier in the membrane of the avian salt gland. The proposed scheme for Na^+ transport involves a cycle in which disodium phosphatidate is formed at the inner surface of the membrane from diglyceride, adenosine triphosphate (ATP), and 2 Na^+, and is hydrolysed to diglyceride, orthophosphate and 2 Na^+ near the outer surface of the membrane. One of the more important questions which we would like to test in relation to this scheme is whether the rate of renewal of phosphate in phosphatidic acid is compatible with the expected rate of Na^+ transfer across the membrane.

The time-courses of the responses in this tissue can give some indication as to whether this rate is compatible with the proposed scheme. Initially, albatross salt gland slices were incubated for 90 min. in the presence of orthophosphate-phosphorus-32; various concentrations of acetylcholine (plus eserine) were then added to the medium. With each concentration of acetylcholine, samples taken at 10-min. and 20-min. intervals after the addition of acetylcholine showed the same amount of radioactivity in the phosphatidic acid with respect to the radioactivity of the orthophosphate (and the ATP) of the tissue (Table 1). The radioactivity levelled off at different and successively higher values with increasing concentrations of acetylcholine. The incorporation of phosphorus-32 into phosphatidic acid was measured at shorter intervals of time after the addition of acetylcholine in goose salt gland slices. After addition of acetylcholine, the radioactivity of the phosphatidic acid showed a rapid increase; this radioactivity reached a maximum value 1–2 min. after the addition of acetylcholine to the medium, and then levelled off and maintained this same value relative to the specific activity of the precursor for the remainder of the period tested, which was up to 20 min. after the addition of acetylcholine (Fig. 1).

To test that the levelling off of the radioactivity in phosphatidic acid was not due to a cessation of response to acetylcholine, albatross salt-gland slices were incubated with acetylcholine (10^{-4} *M*) plus eserine (10^{-4} *M*) for 90 min. before addition of phosphorus-32 to the medium; the slices were removed from the incubation bath 30 min. after the addition of phosphorus-32. Five times as much radioactivity was found in the phosphatidic acid from stimulated slices as compared with the controls. These results show that whatever the mechanism responsible for the increased incorporation of phosphorus-32 into phosphatidic acid in response to acetylcholine, this mechanism was still operating in response to acetylcholine even after 90 min. of exposure to this agent.

Table 1. The Response of Albatross Salt-Gland Slices, to Different Concentrations of Acetylcholine

Additions (molar concentration)		Radioactivity of phosphatidic acid (c.p.m. per milligram fresh weight of tissue)	
Acetylcholine	Eserine		
0	0	50	
		10 min. after acetylcholine added	20 min. after acetylcholine added
10^{-7}	10^{-4} *M*	107	109
10^{-6}	10^{-4} *M*	150	176
10^{-5}	10^{-4} *M*	200	217
10^{-4}	10^{-4} *M* *	228	224

Slices of albatross salt gland were incubated in bicarbonate saline with glucose (1 mgm. per ml.) and phosphorus-32 for 90 min. before the addition of acetylcholine and eserine. The radioactivity is expressed as total counts per min. (c.p.m.) in the phosphatidic acid from 1 mgm. fresh weight of tissue, corrected to a radioactivity of 10^8 c.p.m. per mgm. fresh weight of tissue for the orthophosphate of the tissue. Under these conditions of pre-incubation the specific activity of the 7-min. acid hydrolysable-phosphate of the ATP of the tissue was the same as that of the orthophosphate of the tissue. The values for phosphatidic acid radioactivity given are the averages from two experiments.

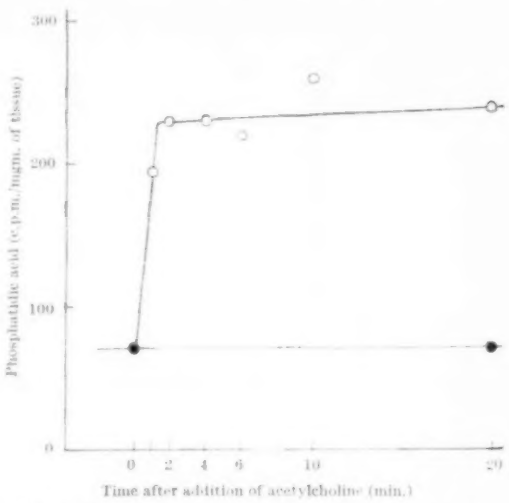


Fig. 1. Time-course of the incorporation of phosphorus-32 into phosphatidic acid on addition of acetylcholine in goose salt-gland slices. The slices were incubated with orthophosphate-phosphorus-32 for approximately 2 hr. before the addition of acetylcholine (10^{-4} *M*) and eserine (10^{-4} *M*). The radioactivity is expressed as in Table 1. The experiment was carried out three times; in each experiment slices from the same animal were incubated in triplicate for each point. Each value given is therefore the average of nine separate estimations on slices from three animals. ○, samples to which acetylcholine was added; ●, control samples incubated over a comparable time without the addition of acetylcholine

Since the renewal of phosphate in phosphatidic acid in response to acetylcholine is taking place throughout this time of exposure to acetylcholine, the maintenance of a constant level of radioactivity in the presence of a given concentration of acetylcholine must mean that a fraction of the phosphatidic acid of the cell has reached equilibrium with the precursor ATP and that this fraction is turning over without any mixing with the other phosphatidic acid of the slice. The step-wise activation in the presence of increasing amounts of acetylcholine presumably indicates the presence in the membrane of receptor sites associated with the turnover of phosphatidic acid which have different threshold values for activation by acetylcholine.

When all the activated phosphatidic acid is in equilibration with its precursor (that is, the specific activity of the activated phosphatidic acid fraction is the same as that of the ATP from which its phosphate is derived), it is not possible to calculate the rate of renewal of phosphate in the relevant phosphatidic acid fraction. This could be very great. Theoretically, the rate of renewal might be obtained from the time taken for the active fraction to reach equilibration with the ATP. However, in order for this to be related to the amount of Na^+ transported during this time, the measurement must be made under conditions in which there is instantaneous and simultaneous activa-

tion of all the sites which respond to a given concentration of acetylcholine. Approximate calculations indicate that, under such ideal conditions, equilibration would be expected to take place within a few seconds of activation. Experimentally, however, these conditions cannot be achieved in salt gland slices. It takes an appreciable time for the added acetylcholine to completely permeate the slice and to activate all the possible sites. Some lag in response can therefore be anticipated in this type of experiment due to non-synchronous activation of all the responsive sites. In view of this, the fact that an activated fraction of the phosphatidic acid reaches the specific activity of its precursor within 2 min. after the addition of acetylcholine to the medium is encouraging. It indicates that the rate of renewal of phosphate in the relevant phosphatidic acid could be sufficiently great to account for Na^+ transport by the mechanism which we have proposed.

This work was aided by grants from the United Cerebral Palsy Research and Educational Foundation, the National Institute of Neurological Diseases and Blindness, and the Wisconsin Alumni Research Foundation. It will be published in detail elsewhere.

MABEL R. HOKIN
LOWELL E. HOKIN

Department of Physiological Chemistry,
University of Wisconsin, Madison 6.

[1] Hokin, L. E., and Hokin, M. R., *J. Gen. Physiol.*, **44**, 61 (1960).
[2] Hokin, L. E., and Hokin, M. R., *Internat. Rev. Neurobiol.*, **2**, 99 (1960).

Impairment of Erythropoiesis by Irradiation

THERE is much evidence that erythropoiesis is regulated by at least one humoral factor, erythropoietin[1], the chemical composition of which is considered to be that of a glycoprotein[2]. Investigations indicate that this hormone induces erythrocyte production by stimulating differentiation of primitive cells of the reticulum[3–5].

The ideal nature of the transfusion-induced polycythæmic mouse for *in vivo* studies of erythropoiesis was first demonstrated by Jacobson *et al.*[3]. Recently we have described the orderly wave of erythropoiesis which sweeps through the reticulum of such animals in response to a single injection of erythropoietin[6]. This communication records preliminary work on the impairment of this response produced by total-body X-irradiation of plethoric mice.

Virgin female *CF* No. 1 mice, 7–8 weeks of age, were made polycythæmic by single intraperitoneal injections of 1 ml. of packed red cells from retired breeder mice of the same strain given on two consecutive days. Five days after the second transfusion, hæmatocrits averaged approximately 75 per cent, and the absence of reticulocytes from the peripheral blood, and of morphologically identifiable red cell precursors from bone marrow and spleen, indicated that erythropoiesis was practically eliminated. These mice now received varying doses of total-body X-irradiation (250 kV., 30 m.amp., target distance 79 cm., filter 1/4 mm. copper plus 1 mm. aluminium). Within 30 min. after completion of irradiation, animals were given a single subcutaneous injection of 6 units[7] of erythropoietin dissolved in 0·25 ml. saline, a dose which we have previously demonstrated will evoke maximal erythropoietic response[6]. Two days after this injection (when concentration of normoblasts in the marrow and spleen is rising, and the first reticulocytes are appearing in the peripheral blood of unirradiated controls)[6], each animal received 1 mc. of iron-59 citrate through the tail vein. Four days after this radioiron injection, blood was withdrawn by cardiac puncture, and the percentage iron-59 incorporated in newly formed peripheral red cells was determined[1].

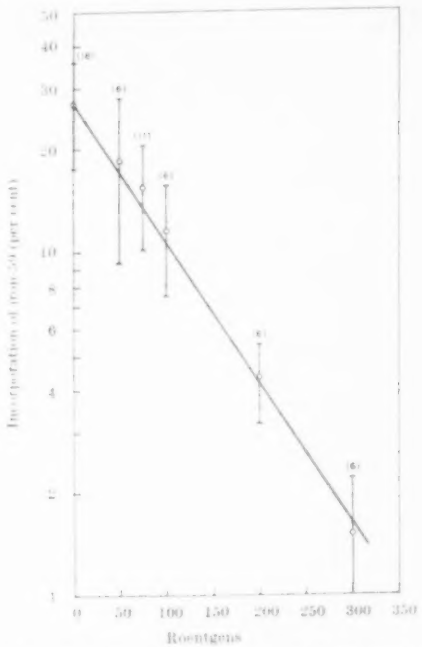


Fig. 1. Impaired response to erythropoietin in the irradiated polycythæmic mouse. Number of mice in brackets

Fig. 1 shows the percentage radioiron incorporation in the red cells of control and irradiated animals plotted on a vertical logarithmic scale. Results are expressed as mean values ± 1 standard deviation, and the number of animals in each group is indicated in parenthesis. Although variation within any group is great, particularly at the lower doses of radiation, mean values indicate that the response of a given group can be predicted, and the suppressive effect of as little as 50 r. is clearly demonstrated. (In a group of mice receiving 400 r., incorporation of radioiron was only 0·6 per cent, indicating almost complete suppression of erythropoiesis.)

While the suppressive effect of radiation on erythropoiesis has been clearly described by previous authors[8], these preliminary results seem worth reporting because they describe a simple quantitative method of evaluating it. In addition, they suggest a way of investigating the sensitivity to irradiation of the stem cells *in vivo*. Since erythropoiesis is virtually suspended in the hypertransfused mouse at the time of irradiation, it seems reasonable to attribute its suppression, as measured by red cell iron-59 incorporation, to the direct action of radiation on the undifferentiated red cell precursors, although an indirect mechanism may also be contributory. Decreased iron-59 incorporation by newly formed red cells is probably not primarily a reflexion of changes in the plasma iron-level following irradiation, since we have recently demonstrated a high level of plasma iron in

hypertransfused rats, which, unlike the plasma iron in normal animals, is not further elevated following radiation (Gurney, C. W., and Taylor, K. T., unpublished results). It must be stressed that only effective erythropoiesis is being measured, and future investigation must also include a study of the blood-forming organs to assess the degree to which stem cells damaged by irradiation undergo differentiation and then succumb while still erythrocyte precursors.

In addition to affording a means for the simple quantitative determination of irradiation damage and recovery of a population of cells, we believe this model offers possibilities for investigation into the nature and kinetics of the stem-cell compartment, and it is for these reasons that these preliminary observations are reported.

We are indebted to L. O. Jacobson for discussion of the problem and for constructive criticism of the manuscript.

C. W. Gurney*
Nancy Wackman

Argonne Cancer Research Hospital† and Department of Medicine,
University of Chicago.

* John and Mary Markle Foundation Scholar.
† Operated by the University of Chicago for the United States Atomic Energy Commission.

[1] Jacobson, L. O., Gurney, C. W., and Goldwasser, E., *Advances in Internal Medicine*, **10**, 297 (1960).
[2] White, W., Gurney, C. W., Goldwasser, E., and Jacobson, L. O., *Recent Progress in Hormone Research*, **16**, 219 (1960).
[3] Jacobson, L. O., Goldwasser, E., Plzak, L. F., and Fried, W., *Proc. Soc. Exp. Biol. Med.*, **94**, 243 (1957).
[4] Alpen, E. L., and Cranmore, D., *The Kinetics of Cellular Proliferation*, 290 (Grune and Stratton, New York, 1959).
[5] Erslev, A. J., *Blood*, **14**, 386 (1959).
[6] Filmanowicz, E., and Gurney, C. W., *J. Lab. Clin. Med.*, **57**, 65 (1961).
[7] Goldwasser, E., and White, W., *Fed. Proc.*, **18**, 236 (1959).
[8] Bloom, M. A., and Bloom, W. J., *J. Lab. Clin. Med.*, **32**, 654 (1947). Hennessy, T. G., and Huff, R. L., *Proc. Soc. Exp. Biol. Med.*, **73**, 436 (1950). Jacobson, L. O., Marks, E. K., Simmons, E. L., Hagen, C. W., and Zirkle, R. E., *Biological Effects of External X and Gamma Radiation*, 265 (McGraw-Hill Co., New York, Part 1, National Nuclear Energy Series, 22B, 1954). Baxter, C. F., Belcher, E. B., Harriss, E. G., and Lamerton, L. F., *Brit. J. Haemat.*, **1**, 86 (1955).

Development of the Islets of Langerhans in Man

Very little has been published about the differentiation of the α and β cells in the development of the pancreatic islets in man. The only work since the introduction of the modern granule stains is that of Ferner and Stoeckenius[1] (based on twelve fœtal pancreases), and Schultze Jena[2] (based on six fœtal pancreases).

The material for the present work was 36 pancreases from human fœtuses with weights ranging from 34–3,000 g.n. (10 wk. gestation to full term), stained by Gomori's chrome-alum hæmatoxylin phloxin method[3] and/or by chrome-alum hæmatoxylin with Gomori's one-stage trichrome counterstain. Eleven pancreases were from fœtuses between 10–20 wk. gestation. It is the islets in these early months of gestation, in particular, which have not been adequately described before.

Four stages are observed in the development of the islets. These overlap so that any one pancreas will show islets in more than one stage:

(1) State of budding islets. In the third gestational month, clusters of islet-cells bud off from the ducts. Differentiated α and β cells are already present. The β cells form a central cluster, around which ungranulated islet-cells and occasional α cells are ranged.

(2) Bipolar stage. As the islets grow, the β cells become grouped at the tip of the islet farthest from the duct, while the α cells form a calyx at the base of the islet. The proportion of ungranulated cells diminishes. Islets in this bipolar phase are observed from the fifth to the eighth gestational month.

(3) 'Mantle-islet' stage. The α cells at the base of the islets proliferate and grow right round the β cells. The islet now has a kernel of β cells and a shell of α cells. Some ungranulated cells are still present among the α cells.

There is a good deal of overlapping between the bipolar and mantle-islet stages. Mantle-islets are seen as early as the fifth gestational month, and dominate the picture from about the sixth gestational month.

(4) Stage of mature islets. From the eighth gestational month onward, a few islets can be found where the α and β cells have the more-or-less haphazard distribution characteristic of the mature adult islet, although the majority are 'mantle-islets' right up to term and beyond.

A detailed account of this work, with photomicrographs, will be reported elsewhere.

Patricia M. Robb

Department of Pathology,
Dumfries and Galloway Royal Infirmary,
Dumfries, Scotland.

[1] Ferner, H., and Stoeckenius, W., *Z. für Zellforsch. u. Mikr. Anat.*, **35**, 173 (1949).
[2] Schultze Jena, B. S., *Arch. Path. Anat.*, **323**, 653 (1953).
[3] Gomori, G., *Amer. J. Path.*, **17**, 395 (1941).

PATHOLOGY

Serological Tests for Toxoplasmosis

Interest in various serological tests for toxoplasmosis has increased considerably in recent years. Siim and Lind[1], in a preliminary communication, have recently described a flocculation test using toxoplasma antigen adsorbed on to acrylic particles. They stated that preliminary results of absorption experiments showed the existence of more than one toxoplasma antigen. The following experiments carried out in this Laboratory may be of interest.

A high-titre human antitoxoplasma serum was absorbed with toxoplasma-infected mouse peritoneal exudate at room temperature (20° C.). This removed almost all the hæmagglutinating, complement-fixing and dye-test antibodies. Absorption of the same serum overnight with human red cells coated with toxoplasma antigen (as used in the hæmagglutination test of Jacobs and Lunde[2]) removed the hæmagglutinating antibody but the dye test and complement-fixation antibodies were unaffected.

Control tests were set up using a normal human serum, absorbed with toxoplasma suspension, and a normal human serum absorbed with red cells coated with toxoplasma antigen. This experiment excluded effects due to elution of soluble toxoplasma antigen. Absorption of the antitoxoplasma serum with human unsensitized cells did not alter the titres of the dye, hæmagglutinating or complement-fixing antibodies. The results are summarized in Table 1.

The results of this experiment were substantiated by using a HeLa cell tissue culture toxoplasma antigen to absorb a hyperimmune serum from another patient. The effect of using a tissue culture antigen

Table 1. Absorption of antitoxoplasma serum

	Dye test	Hæmagglutination test	Complement-fixation test
Antitoxoplasma serum unabsorbed	Positive at 1/1,280	Positive at 1/1,280	Positive at 1/640
Antitoxoplasma serum absorbed with toxoplasma suspension	Positive at 1/40	Negative at 1/20	Negative at 1/20
Antitoxoplasma serum absorbed with sensitized human red cells	Positive at 1/1,280	Negative at 1/20	Positive at 1/1,280
Antitoxoplasma serum absorbed with unsensitized human red cells	Positive at 1/1,280	Positive at 1/1,280	Positive at 1/1,280
Normal human serum control absorbed with toxoplasma suspension and then mixed with antitoxoplasma serum	Positive at 1/640	Positive at 1/320	Positive at 1/640
Normal human serum control absorbed with sensitized human red cells and then mixed with antitoxoplasma serum	Positive at 1/640	Positive at 1/640	Positive at 1/640

as an absorbent was essentially the same as that with the mouse exudate antigen.

These experiments demonstrate that the antibody measured in the hæmagglutination test differs from that in either the dye or complement-fixation tests. Therefore the antigen or antigens responsible for the hæmagglutination test differ from those responsible for the dye and complement-fixation tests.

D. G. Fleck

Public Health Laboratory,
Cockett Road, Swansea.

[1] Siim, J. C., and Lind, K., *Acta Path. Micro. Scand.*, **50**, 445 (1960).
[2] Jacobs, L., and Lunde, M. N., *J. Parasitol.*, **43**, 308 (1957).

Effect of a Magnetic Field on Sarcoma 37 Ascites Tumour Cells

This communication deals with work on the effect of magnetic field on living ascites tumour cells *in vitro*. The hanging-drop culture was prepared by diluting a 7-day-old transplanted ascites mouse tumour with suitable aliquots of Tyrode solution. The culture slide to be exposed to the field was then placed between the poles of an Alnico permanent magnet in a horizontal position at a constant temperature of 37° C. The field strength used during the experiment was about 4,000 gauss and was determined independently by the susceptibility technique. The control slides not exposed to the field were treated identically. The microscopic examination of the slides was carried out periodically.

The control tumour cells showed normal growth and active differentiation, even after 18 hr., whereas most tumour cells exposed to the field showed complete degeneration at the end of this period. These experiments were repeated several times with reproducible results. The slides made after 18 hr. were stained with acetocarmine and photomicrographs were made.

Although it is not possible to explain these results clearly at the present time, the following postulates and assumptions are considered in working out a hypothesis for this purpose. (1) The 'chemical components' in the cells have varying magnitudes of magnetic susceptibility representing the diamagnetic and the permanent and any transient paramagnetic contributions. Hence, the permanent and any transient components will experience varying forces under the influence of the magnetic field. (2) Although these forces are small from a macroscopic point of view, they may be enough to upset the delicate balance (chemical and other equilibria) inside and outside the cell. (3) Such changes are assumed, at least in part, to produce the degeneration of the cells.

We wish to thank Dr. G. S. Sporti for his encouragement and Messrs. Albert Gerth and Robert Neagele for their valuable assistance. Further work on the effect of a magnetic field on living cells will be published elsewhere.

Indumati L. Mulay

Institutum Divi Thomæ,
Cincinnati 6, Ohio.

L. N. Mulay

Chemistry Department,
University of Cincinnati,
Cincinnati 21, Ohio.

Association of Detectable Antibodies produced by *Haemonchus* spp. Infections in Cattle, with Serum Globulin Fractions

Earlier investigations have shown that cattle which exhibit a marked degree of natural resistance to infection with *Haemonchus* spp. also develop higher complement-fixation titres than susceptible cattle, and that rises in the complement-fixation antibody titres often occurred at the same time as rises in the gamma one fraction of the serum globulin. This resistance has been shown to be heritable[1,2]. These observations were made under field conditions where extraneous stimuli were likely to produce changes in the globulin fractions, so that the correlation between complement-fixation titres and the γ-1-globulin fraction was not always consistent and definite conclusions were not possible. To clarify this situation, cattle sera known to be positive by the complement-fixation test were fractionated and the fractions identified and tested for antibody content. The following is a brief account of the procedure and results obtained.

The β- and γ-globulins were first separated from the serum by precipitation with 16 per cent sodium sulphate at 37° C. The globulin was further fractionated on a diethylaminoethyl cellulose chromatographic column with gradient potassium acid phosphate buffer solutions ranging from *p*H 7·0, 0·005 *M* to *p*H 5·8, 0·1 *M*, after the technique in refs. 3 and 4. Three antibody positive fractions were isolated in this manner. The protein content of these fractions was estimated by the biuret colorimetric method[5,6]. The relative concentration of the individual globulins in these fractions was ascertained by adding them to a known standard serum and observing the alteration in the globulin fraction content of the serum by electrophoresis in an Antweiler microelectrophoresis apparatus. Complement-fixation test techniques were carried out as described in ref. 1, and hæmagglutination tests following the method in refs. 6 and 7.

Considerable variation occurred in the relative amount of total protein in the samples, and antibody contents have therefore been expressed as antibody potency per gm. of protein. Complement-fixation test results have been expressed as 'index ratios' (refs. 2 and 8), which is the ratio of the amount of complement fixed by the serum in the presence of antigen to the amount fixed in the absence of antigen, after corrections, if necessary, have been made for anti-complementary effects of the antigen. Details of the results are shown in Table 1.

Table 1. Analysis of Original Serum and Three Column Fractions

Serum specimen	Electrophoresis analysis. Per cent content of globulins				Protein content gm./100 ml.	Complement-fixation index ratio per gm. of protein	Hæmagglutination titre per gm. of protein
	Beta 1	Beta 2	Gamma 1	Gamma 2			
Original whole serum	12	28	28	32	1·36*	12·5	1/24
Column fraction 1	0	25	25	50	0·07	21	Neg.
Column fraction 2	0	70	30	0	0·09	33	1/22
Column fraction 3	52	48	0	0	0·06	Neg.	1/33

* Beta and gamma only.

The results support the original suggestion that the complement-fixation antibody is located principally in the γ-1-globulin, and also show that the hæmagglutination antibody is present in the β-globulin fraction, principally in the β-2-globulin. It has been demonstrated by other workers that the complement-fixation and hæmagglutination antibodies are independent in animals infected with *Haemonchus* spp. and the above findings confirm this.

There are at present insufficient data available to form definite conclusions as to the role of the globulin fraction in resistance to *Haemonchus* spp. infection in cattle, but there would, however, appear to be a possible association between the complement-fixation antibody, rises in the γ-1-fraction of the γ-globulins and the occurrence of a natural immunity. Present investigations into the host–parasite relationship in hæmonchosis in this laboratory suggested that rises in the γ-2-fraction of the γ-globulin may be associated with an acquired resistance to the disease.

J. G. Ross

Federal Veterinary Department,
Vom, Nigeria.

[1] Ross, J. G., Lee, R. P., and Armour, J., *Vet. Rec.*, **71**, 2, 27 (1959).
[2] Ross, J. G., Armour, J., and Lee, R. P., *Vet. Rec.*, **72**, 7, 119 (1960).
[3] Peterson, E. A., and Sober, H. A., *J. Amer. Chem. Soc.*, **78**, 751 (1956).
[4] Sober, H. A., Gutter, F. J., Wyckoff, M. M., and Peterson, E. A., *J. Amer. Chem. Soc.*, **78**, 756 (1956).
[5] Weichselbaum, T. A., *Amer. J. Clin. Path.*, **10**, 40 (1946).
[6] Boyden, S. V., *J. Exp. Med.*, **93**, 107 (1951).
[7] Soulsby, E. J. L., *J. Helm.*, **30**, 129 (1956).
[8] Rice, C. E., *J. Immunol.*, **43**, 2, 129 (1942).
[9] Stewart, D. F., *The Immune Reactions to Nematode Infections* (International Veterinary Congress, Madrid, 1959).

HÆMATOLOGY

Significance of the Presence of Lewis Substances in Serum during Infancy

It has been found that infants who develop into adults with the following phenotype: red cells Le (a − b +), ABH secretor, Les (a + b +)[a], go through a phase in which the red-cell phenotype is Le (a + b +), and the secretions, as in the adult, contain ABH, Le[a] and Le[b]. We have been able to establish that during the phase in which Le[a] substance is detectable on the red cells of these infants, it is also detectable in their serum. In the adult with Le (a − b +) red cells, although Le[b] substance is present in serum, Le[a] substance is not detectable although it is found in the water-soluble secretions. Our observations are summarized in Table 1.

[a] Les = Lewis substances in saliva.

Table 1

	Red cells		Serum		Saliva	
	Le[a]	Le[b]	Le[a]	Le[b]	Le[a]	Le[b]
Infant	+	+	−	+	+	+
Adult	−	+	−	+	+	+
Infant / Adult	+	−	+	−	+	−
Infant / Adult	−	−	−	−	−	−

The explanation of the infant Le (a + b +) red-cell phenotype appears to be that the Lewis substances he or she is capable of producing are present throughout the body. We can assume that the disappearance of detectable Le[a] substance from the circulation is related to the interactions of Lewis, ABO and secretor systems. There is already evidence for this in the case of some A_1 Le (a − b +) individuals in whom the Le[b] substance is present in low concentration on cells and in serum, and the power to detect it depends on the potency of the antisera. In our tests for Lewis substances in serum we diluted the sera 2·3 with saline, and added one volume of this to each tube of a titration of the Lewis antisera 1/1–1/16. We were fortunate in having antisera with titres respectable enough to perform the tests and for these we are indebted to Dr. I. Dunsford.

Roman type has been used for the symbols which represent phenotypes, in order to observe a convention in genetics that phenotypes are shown in Roman type and genes in italics.

Sylvia D. Lawler

Royal Marsden Hospital,
London, S.W.3.

Ruth Marshall

Galton Laboratory, University College,
London, W.C.1.

Detection of C-Reactive Protein by Fluorescent Antibody Techniques

The presence of *C*-reactive protein in human serum is a highly sensitive index of inflammation or of tissue destruction[1]. It appears in the blood serum as early as 14 hr. after the injury occurs. Present knowledge points towards its being a β-globulin[2], but its origin and function are yet unknown. The methods available for the detection of *C*-reactive protein are based on precipitation[3,4], complement-fixation[5], hæmagglutination[6] and gel-diffusion[7] techniques, methods which are unsuitable for the precise localization of the substance in cells. For this purpose the fluorescent antibody technique seemed to be promising. Results of staining blood smears from people who are positive and negative for *C*-reactive protein with the fluorescent antibody techniques are described here.

Smears were made on glass slides either directly from blood taken from a finger prick or from clotted venous blood. The smears were air-dried and fixed for 10 min. in 95 per cent ethanol. The presence of *C*-reactive protein in the serum was determined in each case by the usual capillary precipitation method[4] with *C*-reactive protein anti-serum prepared in rabbits. The antiserum, purchased from Schieffelin, of New York, was also used for labelling with fluorescein *iso*thiocyanate. Labelling was carried out by the method of Marshall *et al.*[8]. The fluorescent solution was absorbed twice, once with monkey liver powder and once with guinea pig liver powder[9], and passed

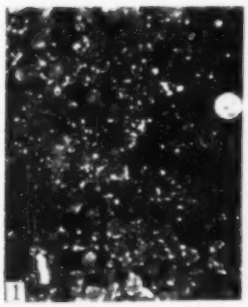


Fig. 1. Fluorescent antibody staining of *C*-reactive protein in blood smear taken from finger. Fluorescent *C*-reactive protein antibody in buffered saline. Leucocyte shows non-specific staining. (× 320)

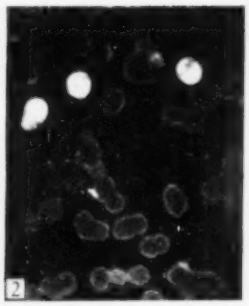


Fig. 2. Inhibition of fluorescent antibody staining of *C*-reactive protein in blood smear taken from finger. Fluorescent *C*-reactive protein antiserum diluted in concentrated *C*-reactive protein. Staining of the latter was completely inhibited, but leucocytes continue to show non-specific staining. (× 320)

through a column of 'Dowex 2' (ref. 10). This labelled *C*-reactive protein antiserum was used diluted 1 : 8.

Both direct and indirect staining methods were used. The direct method consisted of covering the blood smears with the labelled *C*-reactive protein antiserum and allowing them to stand for 30 min. in a moist atmosphere. The smears were then rinsed for 10 min. in buffered saline, mounted under a cover-slip in glycerol saline at *p*H 7·6 and examined. The indirect method was carried out as follows. Smears were covered with unlabelled *C*-reactive protein antiserum and allowed to stand for 30 min. in a wet chamber. The smears were then washed for 10 min. in buffered saline and covered with labelled anti-rabbit globulin. For the rest the procedure was as described above. Smears were examined from persons who were negative to the *C*-reactive protein by the capillary precipitation method and from persons showing various amounts of *C*-reactive protein in their serum.

Particles with intense green fluorescence, ranging in size from the barely visible to approximately 0·3μ, were present in 20 out of 25 people giving a positive response for *C*-reactive protein (Fig. 1). There was rough correspondence between the degree of the capillary precipitation and the quantity of fluorescing particles. Such fluorescing particles were not found in smears of people giving a negative response for *C*-reactive protein. Leucocytes of people giving a positive and those giving a negative response for *C*-reactive protein, as well as those of various laboratory animals, showed slight to intense fluorescent staining. This non-specific staining could be obviated by the addition of normal rabbit, sheep or guinea pig serum to the conjugated *C*-reactive protein antiserum. Thrombocytes from *C*-reactive protein-negative and -positive people, collected separately and stained as above, were negative.

A series of tests was carried out to demonstrate the specificity of the staining. Conjugated normal rabbit serum, when used instead of rabbit *C*-reactive protein antiserum, failed to demonstrate fluorescent staining. The conjugated *C*-reactive protein antiserum was diluted 1 : 8 in saline, and normal rabbit serum, normal sheep serum, normal human serum, concentrated *C*-reactive protein solution prepared from ascitic fluid[2] and in unlabelled *C*-reactive protein antiserum. The normal rabbit and sheep serum did not interfere with the appearance of the stained particles described above, but inhibited the non-specific leucocyte staining. In the presence of unlabelled *C*-reactive protein antiserum, no staining was observed, either of the particles or of leucocytes; in the presence of concentrated *C*-reactive protein, the staining of the particles only was inhibited (Fig. 2). Surprisingly, labelled *C*-reactive protein antiserum when diluted in some normal human sera also failed to show staining. In the indirect staining procedure, the same results were observed in the staining as well as in the inhibition tests. Here also some normal human sera inhibited staining of the fluorescent particles.

Similar findings were obtained with impression smears and frozen sections from spleen, lymph nodes and liver taken *post mortem* from a patient whose serum gave a positive response to *C*-reactive protein. Fluorescent particles were observed as in the blood smears, but did not seem to be associated with any particular cell.

One of the puzzling features of this work is the fact that some specimens of serum taken from apparently healthy laboratory workers interfered with the fluorescent staining. This interference was observed both in the direct and indirect staining procedures. Seligman *et al.*[11] found traces of *C*-reactive protein in many normal human sera. Assuming that the inhibition of staining is more sensitive than the capillary precipitation reaction, one might speculate that the apparently normal sera which inhibited staining contained traces of *C*-reactive protein. The failure to detect the latter in leucocytes by the fluorescent technique is in agreement with the findings of Seligman *et al.*[11], who were unable to detect it in extracts of normal and leukæmic cells.

This investigation was aided by a grant from the Hadassah Medical Organization Research Fund.

ROBERT GOLDWASSER

Israel Institute for Biological Research,
Ness Ziona.

RACHMIEL ROZANSKY

Department of Clinical Microbiology,
Hadassah University Hospital and Hebrew University
Hadassah Medical School,
Jerusalem.

[1] Roantree, R. J., and Rantz, L. A., *Arch. Int. Med.*, **96**, 674 (1955).
[2] Wood, H. F., McCarty, M., and Slater, R. J., *J. Exp. Med.*, **100**, 71 (1954).
[3] Tillet, W. S., and Francis, T., *J. Exp. Med.*, **52**, 561 (1930).
[4] Anderson, H. C., and McCarty, M., *Amer. J. Med.*, **8**, 445 (1950).
[5] Muschill, L. H., and Weatherwax, J., *Proc. Soc. Exp. Biol. Med.*, **87**, 191 (1954).
[6] Gal, K., and Miltenyi, M., *Acta Microbiol. Hung.*, **3**, 41 (1955).
[7] Libretti, A., Kaplan, M. A., and Goblin, M., *Proc. Soc. Exp. Biol. Med.*, **90**, 481 (1955).
[8] Marshall, J. D., Eveland, W. C., and Smith, C. W., *Proc. Soc. Exp. Biol. Med.*, **98**, 898 (1958).
[9] Coons, A. H., Leduc, E. H., and Connolly, J. M., *J. Exp. Med.*, **102**, 49 (1955).
[10] Coons, A. H., *General Cytochemical Methods*, edit. by Danielli, J. F., **1**, 399 (Acad. Press, New York, 1958).
[11] Seligman, M., Alais, L., and Bernard, J., *Rev. Franc. d'Etudes Clin. et Biol.*, **4**, 901 (1959).

HISTOCHEMISTRY

Nature of the Sinus Lining Cells of the Spleen

VARIOUS opinions have been expressed on the nature of the cells lining the venous sinusoids of the spleen[1]. They have been described as forming a type of internal epithelium, as muscle cells and as separated, longitudinal endothelial ridges. Klemperer

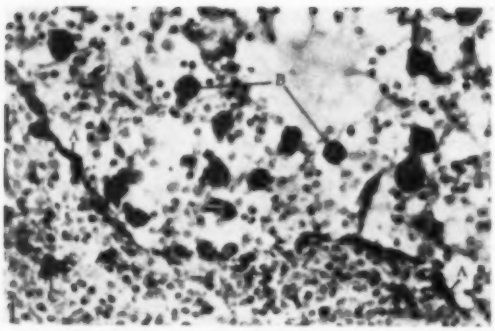


Fig. 1. Frozen section of a lymph node demonstrating non-specific esterase activity in histiocytes, (*A*) lining sinuses (littoral cells), (*B*) lying free in dilated sinus, (*C*) in medulla. α-Naphthyl acetate method. (× *c.* 240)

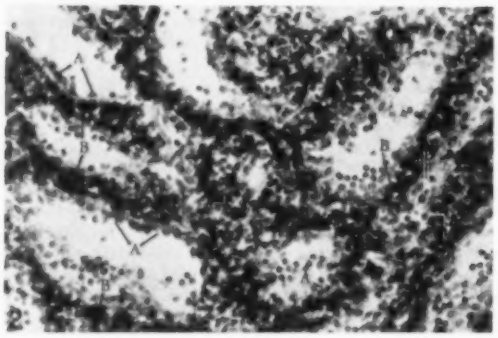


Fig. 2. Frozen section of spleen demonstrating non-specific esterase activity in histiocytes, (*B*) in cords of Billroth, but not in sinus lining cells (*A*). α-Naphthyl acetate method. (× *c.* 150)

accepted Mollier's evidence[2] that the wall of a splenic sinus is formed by a cytoplasmic reticulum with reinforcing fibres, essentially identical to the general cytoplasmic and fibrillar reticulum of the pulp. As recently as 1957 Weiss[3] stated that splenic cords are collapsed splenic sinuses, and the preponderant cell type in the cords is the same as that lining sinuses.

It is evident that interpretations of histological appearances, whether under the light or electron microscope, are influenced by artefacts. Other methods of study may therefore be more fruitful.

Braunstein *et al.*[4], from enzyme histochemical studies, regarded the splenic littoral cells as histiocytes, that is, phagocytic cells like those of lymph nodes, Kupffer cells, reticuloendothelial cells of bone-marrow and monocytes of blood. They stated further that all histiocytes manifest strong non-specific esterase and acid phosphatase activity. They also demonstrated strong alkaline phosphatase activity in capillary and lymphatic endothelium. From this study it would appear that splenic sinusoids are comparable with those of liver in that they are lined by phagocytes.

Using the histochemical techniques described by Pearse[5] for acid and alkaline phosphatase and non-specific esterase, on formalin-fixed frozen sections, I have confirmed the results of Braunstein *et al.*, in regard to the histiocytes of lymph nodes. I have not, however, been able to confirm their statements concerning the splenic sinus lining cells.

The spleens studied were obtained from monkeys, guinea pigs and human patients. The last-named group comprised two patients with lacerated spleens, two with thalassæmia, three with hereditary spherocytosis and one with thrombocytopenic purpura. In all these, non-specific esterase and acid phosphatase were demonstrable in stellate, branching histiocytes in the cords of Billroth and in Malpighian corpuscles. The sinus lining cells, however, were consistently negative for all three enzymes.

Capillary endothelium possessed the characteristic strong alkaline phosphatase activity.

It is of interest to note that Marshall's 'metalophil' technique[6] impregnates those histiocytes in lymph nodes and spleen which show non-specific esterase and acid phosphatase activity. He states, however, that the impregnation of the cells lining the splenic sinuses by metallic methods is often difficult.

These enzymatic reactions provide strong evidence that the splenic sinus lining cells are not identical with histiocytes (reticulum cells) in the pulp and in fact are not true histiocytes.

This work was supported by a grant from the National Cancer Association of South Africa.

R. F. Dorfman
South African Institute for Medical Research,
P.O. Box 1038,
Johannesburg.

[1] Klemperer, P., *Handbook of Hematology*, edit. by Downey, H., **3**, 1587 (Hoeber, New York, 1938).
[2] Mollier, *Arch. mikr. Anat.*, **76**, 608 (1910–11) (quoted by Klemperer).
[3] Weiss, L., *Ann. N.Y. Acad. Sci.*, **73**, 131 (1958).
[4] Braunstein, H., Freiman, D. G., and Gall, E. A., *Cancer*, **11**, 829 (1958).
[5] Pearse, A. G. E., *Histochemistry: Theoretical and Applied*, second edit., 868 (Churchill, London, 1960).
[6] Marshall, A. H. E., *An Outline of the Cytology and Pathology of the Reticular Tissue*, 23, 28 (Oliver and Boyd, Edinburgh, 1956).

MICROBIOLOGY

A Superior Fat-synthesizing Single-spore Strain of *Lipomyces*

Considerable attention has been devoted to the investigation of fat-producing micro-organisms as a potential industrial process. Woodbine[1] has recently reviewed this field and showed that, whereas many strains had been examined for their fat-producing abilities, no rationalized investigation for improving the fat-producing ability of an individual strain by selection had been undertaken. Such a strain could be isolated originally as either a single cell or a spore which could then be subcultured to give a genetically homogeneous strain.

Roberts[2] had isolated some single-spore cultures from strains of the fat-producing yeast genus *Lipomyces* and an investigation was carried out on ten of these strains: *B* to *H* were isolated from a parent culture of *L. lipofer*, and *I* to *L* from a culture of *L. starkeyi*.

Lactose was used as the carbon substrate by all strains (Wickerham's medium). Although *L. lipofer* was found to utilize lactose immediately, *L. starkeyi* required an adaptive period of fifteen or more days. This contradicts the evidence of Connell *et al.*[3], who claimed that none of the strains they examined would utilize lactose, and of Lodder *et al.*[4], who found that only strains of *L. lipofer* would utilize lactose and indeed used this as a diagnostic character. Van der Walt[5] and Roberts[2] found that both species would utilize lactose. One reason for the confusion would appear to be due

Table 1. Results for the low C : N ratio in terms of Total Yield, Sugar Utilized and Total Fat in gm./l. using *L. starkeyi*

Strain designation		Total yield	Sugar utilized	Economic coefficient	Fat per cent	Total fat	Fat coefficient
Parent strain *P*	Mean *S.E.* S.S.D.	11·2 ±0·16 *I,K,L*	29·1 ±1·38 *I,K,L*	38·8 ±0·69 *J*	20·1 ±5·5	2·3 ±0·61 *I,L*	8·1 ±2·07
Strain *I*	Mean *S.E.* S.S.D.	21·9 ±0·84 *P,J*	64·6 ±1·12 *P,J*	34·0 ±1·11 *J*	31·4 ±2·45	7·0 ±0·8 *P,J,K*	10·7 ±1·14
Strain *J*	Mean *S.E.* S.S.D.	13·2 ±2·06 *I,K,L*	28·6 ±1·29 *I,K,L*	50·1 ±6·32 *P,I,K,L*	15·6 ±4·70	3·4 ±1·13 *I,L*	11·8 ±3·85
Strain *K*	Mean *S.E.* S.S.D.	20·1 ±1·5 *J,P*	66·2 ±2·32 *J,P*	30·4 ±0·6 *J*	18·9 ±2·64	3·8 ±0·45 *I,L*	5·8 ±0·95
Strain *L*	Mean *S.E.* S.S.D.	22·9 ±0·7 *J,P*	62·1 ±2·1 *J,P*	36·9 ±0·84 *J*	26·8 ±0·94	7·2 ±1·09 *P,J,K*	11·7 ±1·76

The 'economic coefficient' is dry $\frac{\text{cell weight}}{\text{sugar utilized}} \times 100$, and the fat coefficient is $\frac{\text{fat produced}}{\text{sugar utilized}} \times 100$.

S.S.D. indicates the strains showing a significant difference ($P < 0.05$) by 'difference between means' analysis.

to the long adaptive period required by *L. starkeyi* before it can break down the lactose. This, indeed, might be used as a diagnostic character in the species differentiation of the genus *Lipomyces*.

Examination for variations in the fat-synthesizing abilities of the strains was done on two media, one with a carbon to nitrogen ratio of twenty and the other with a ratio of sixty.

With the low carbon-to-nitrogen ratio, Wickerham's[6] yeast–nitrogen base ('Difco' brand) medium was employed, containing 5 per cent lactose. Five replicates of 50 ml. of medium in 250 ml. Erlenmeyer flasks were used for each strain. The inoculum was subcultured on the glucose agar used by Starkey[3], and 0·5 ml. of a standardized cell suspension used as inoculum. The flasks were agitated at 120 r.p.m. (3 in. thrust) at 26 ± 1° C., and gathered after 33 days. Dry weight, sugar utilization and the fat percentages were assessed by the methods of Wix and Woodbine[7]. *L. lipofer* strains showed no variation, but considerable variation occurred among strains of *L. starkeyi* (Table 1). Although no variation was found with regard to the fat-synthesizing mechanism, all the single spore strains examined were found to have adapted to lactose faster than the parent strain, which had utilized only half the available sugar. Diauxie occurred, so that the 'parent' strain was adapting from the glucose to the galactose (or vice versa) fraction of the lactose when samples were harvested.

Strains *I*, *K*, and *L* had completely utilized the lactose whereas strain *J* was still utilizing the second sugar in the lactose and consequently had a significantly higher economic coefficient. This indicates that single-spore strain selection might produce strains with shorter adaptation periods toward sugars than the original strain.

In the medium with high carbon-nitrogen ratio fat production was encouraged. Six replicates for each strain were grown in 6-oz. medical flat bottles containing 35 ml. of the medium recommended by Starkey[3] but containing 3 per cent lactose. The bottles were laid on their sides to increase aeration and incubated at 26 ± 1° C. No agitation was applied. Inoculation and gathering were carried out in the same manner as in the previous experiment. No deviation occurred among the strains of *L. lipofer*. The total yield, sugar utilization, and economic coefficient trends were similar to those found in the first experiment. The differences may be summarized by division of the strains of *L. starkeyi* into three groups. Strain *P* gave the lowest yield, strains *I*, *J*, and *K* produced greater yields, whereas strain *L* produced the highest. In no case was all the lactose broken down; this is the result of the high C : N ratio of the medium and the relatively poor aeration retarding growth. Sugar utilization by the strains does not show the same pattern as is evident for the total yield, strain *L* having utilized only the same amount of sugar as strain *P*. The higher total yield of strain *L* is reflected in the higher economic coefficient which is significant at a 1 per cent level. Much of this increase has occurred due to the higher rate of fat synthesis in strain *L*. This may be shown by a comparison of the synthesis of non-fatty components for these two strains. For strain *P*, this amounts to 0·98 gm./l., whereas for strain *L* it is 1·10 gm./l., which is an increase of 11·2 per cent. If the fat-synthesizing mechanisms of both strains were similar, then strain *L* would show 11·2 per cent increase in fat produced over strain *P*, since no significant difference in sugar utilization has occurred between the strains. From Table 2, it can be calculated that the increase in fat produced by strain *L* over strain *P* is in fact 163·6 per cent. This exceptional increase in fat could be due to a more efficient synthesizing mechanism being possessed by strain *L* than by strain *P* under the high carbon nitrogen ratio conditions used in this experiment. Strain *I* closely resembles strain *P* in all but total yield, which is significantly higher. This may be due to a greater synthesis of the non-fatty components from the same amount of sugar used. Strains *J* and *K* are very similar to each other; both have used more sugar than the other strains. Most of the increase in total yield appears to be the result of the increased synthesis of non-fatty cell components.

The general conclusion drawn from this work is that by investigation of single-spore isolates from *Lipomyces starkeyi*, strains are found with superior power to assimilate sugar and/or more efficient fat-synthesizing ability to those of the parent strain. The results indicate that improvement in such characteristics might be possible by investigating single spores isolated from a parent strain.

Table 2. Results for the High C : N ratio in Terms of Total Yield, Sugar Utilized and Total Fat in gm./l. using *L. starkeyi*

Strain designation		Total yield	Sugar utilized	Economic coefficient	Fat per cent	Total fat	Fat coefficient
Parent strain *P*	Mean *S.E.* S.S.D.	1·2 ±0·2 *I,J,K,L*	7·6 ±1·39 *J,K*	18·3 ±3·32	7·7 ±4·98 *L*	0·22 ±0·038 *L*	2·16 ±1·52 *L*
Strain *I*	Mean *S.E.* S.S.D.	1·56 ±0·036 *P,L*	7·24 ±0·42 *J,K*	21·9 ±0·85	13·0 ±2·35 *L*	0·216 ±0·0038 *L*	2·96 ±0·66 *L*
Strain *J*	Mean *S.E.* S.S.D.	1·54 ±0·19 *P,L*	11·4 ±0·87 *P,I,L*	14·7 ±1·93	10·9 ±3·04 *L*	0·22 ±0·022 *L*	1·69 ±0·92 *L*
Strain *K*	Mean *S.E.* S.S.D.	1·56 ±0·18 *P,L*	12·8 ±3·07 *P,I,L*	12·8 ±1·53	11·9 ±3·09 *L*	0·33 ±0·03	1·58 ±0·65 *L*
Strain *L*	Mean *S.E.* S.S.D.	1·68 ±0·19 *P,I,J,K*	8·0 ±3·56 *J,K*	31·7 ±10·06	30·6 ±8·06 *P,I,J,K*	0·58 ±0·023 *P,I,J*	10·04 ±1·93 *P,I,J,K*

The advice and provision of cultures by Dr. Catherine Roberts of the Carlsberg Laboratorium, Copenhagen, is gratefully acknowledged.

D. R. CULLIMORE
M. WOODBINE

Microbiological Unit,
Department of Agricultural Sciences,
University of Nottingham.

[1] Woodbine, M., *Progr. Indus. Microbiol.*, **1**, 179 (1959).
[2] Roberts, C., *Nature*, **179**, 1198 (1957).
[3] Connell, G. H., Skinner, C. E. and Hurd, R. C., *Mycologia*, **46**, 12 (1954).
[4] Lodder, J., and Kreger-Van Rij, N. J. W., *The Yeasts—A Taxonomic Study* (North Holland Publish., Amsterdam, 1952).
[5] Van der Walt, J. P., *Leeuwenhoek ned. Tijdschr.*, **23**, 109 (1957).
[6] Wickerham, L. J., *U.S. Dept. Agric. Tech. Bull.* No. 1029 (1951).
[7] Wix, P., and Woodbine, M., *J. Appl. Bact.*, **22**, 14 (1959).
[8] Starkey, R. L., *J. Bact.*, **51**, 33 (1946).

The Cytochrome of *Pasteurella tularensis*

THE examination of cytochrome in bacterial cells has been reported earlier by W. F. Riedmuller[1], A. F. Brodie *et al.*[2], and W. S. Silver[3]. Recently, T. Yamanaka *et al.*[4] have separated and purified cytochrome from *Pseudomonas aeruginosa*. The present communication describes cytochrome components which have been detected in the highly virulent (Idaho, Nevada) strains (LD_{50} 10^{-7}) and avirulent (P38) strain (LD_{50} 32 mgm.) of *P. tularensis*.

Bacterial cells cultured on Hiwatashi's medium for 24 hr. at 37° C. were used. 4 gm. of cells were washed three times with distilled water in a homogenizer and centrifuged for 10 min. at 11,000 r.p.m. Cell-free extracts were obtained by treating the washed cells in a sonic oscillator (9 kc./s.) for 6 min., followed by centrifugation at 11,000 r.p.m. for 10 min. The resulting supernatant was used as the cell-free extract. Freeze-dried cells and frozen cells were prepared by the usual methods.

The optical density was measured with a Shimadzu photo-electric spectrophotometer, type *QB*–50. The absorption spectrum of the cell suspension or cell-free extract was measured using an opal glass, using Calvin and Shibata's method[5]. Cell concentrations were checked by finding the dry weight and by micro-estimation of nitrogen (indophenol method).

Using a hand spectroscope, when excess sodium dithionite was added, the native cells showed absorption bands essentially the same as the virulent and avirulent strains, though an absorption band at around 560 mμ was found to be stronger in the virulent strains (Fig. 1). Similar results were obtained with cells grown for 48 hr. on a blood-free medium.

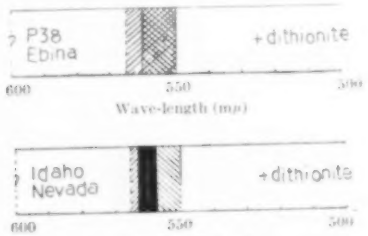
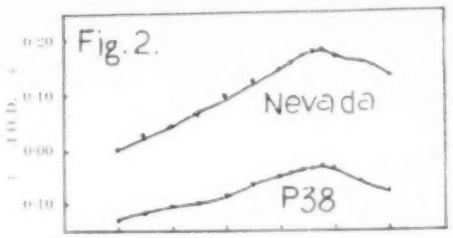
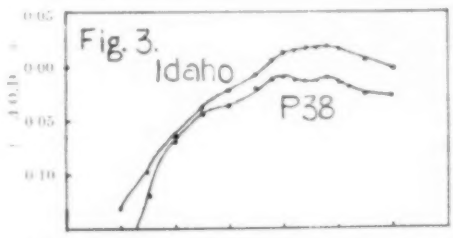


Fig. 1. Cytochrome components of *P. tularensis*. After reduction with sodium dithionate, the samples were examined for their cytochrome components by means of a Zeiss hand-spectroscope at room temperature and during immersion in liquid air





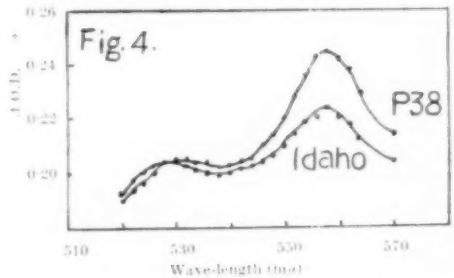


Fig. 2. Freeze-dried cells. Fig. 3. Native cells. Fig. 4. Particles. Optical density (O.D.) represents the difference between the oxidized and reduced forms

(1) Lyophilized cell preparations: 100 mgm. of dry cells were thoroughly dispersed in 10 ml. of 0·2 *M* phosphate buffer (*p*H 7·0) in a homogenizer, and the differential spectra (optical densities) were measured by the difference between cell suspensions previously reduced by excess sodium dithionite and by excess potassium ferricyanide. In Fig. 2, $\Delta E(=E_{max.}-E_{540})$ is plotted against wave-length for the two strains, and $E_{max.}$ is seen to be at 558 mμ:

Virulent strain: $\Delta E = 0{\cdot}17 - 0{\cdot}090 = 0{\cdot}080$
Avirulent strain: $\Delta E = 0{\cdot}040 - (-0{\cdot}100) = 0{\cdot}060$

As the dry weight is the same, cytochrome as measured by ($E_{558-540}$) from the virulent strain is greater by $\Delta E = 0{\cdot}02$ than the avirulent strain.

(2) Resting native cells: 2 gm. of wet cells per 10 ml. of 0·2 *M* phosphate buffer (*p*H 7·0) were suspended by homogenization, and the differential spectra were measured as before. The results are shown in Fig. 3 and Table 1, giving the value of ΔE corrected for the respective protein contents. The latter was remarkably large in the virulent strain, but $E_{max.}$ is still at about 558 mμ.

Table 1. CYTOCHROME ($E_{558-540}$) CONTENTS OF *P. tularensis*

Specimens	Native cells		Particles	
Strain	*P* 38	Idaho	*P* 38	Idaho
ΔE (O.D.)	0·013	0·035	0·042	0·023
N (γ/ml.)	7,880	9,440	5,040	870
ΔE/gm. protein	0·27	0·87	1·33	4·24
Differences		< 0·60		< 2·91

(3) Cell-free extracts: The cell-free particles extracted from the cells as described were examined spectroscopically. When absorption at about 560 mμ due to contamination had been removed, there was a strong alpha-absorption peak at 558 mμ like the so-called cytochrome b_1 (Fig. 4, Table 1).

These particles can be repeatedly oxidized and reduced like other cytochromes, and showed higher succinoxidase activity by the respirometry or reduction of trimethyl tetrazolium chloride than the other fractions[6]. Hence the absorption band at about 558 mμ may well be that of a cytochrome b_1 type pigment.

Thus it seems that *P. talarensis* contains cytochrome b_1, the amount of which in the whole cell and in the cell-free extract is greater for the virulent strain than for the avirulent strain.

This work was aided by a grant from the Department of Biology, Faculty of Science, University of Osaka.

M. Mizuhara
M. Yamanaka

Department of Microbiology,
Osaka Medical College,
Takatsuki-City, Japan.

[1] Werkman, G. H., and Wilson, P. W., *Bacterial Physiology*, 338 (1951).
[2] Brodie, A. F., and Gray, C. T., *Science*, **125**, 534 (1957).
[3] Silver, W. S., *Nature*, **185**, 555 (1960).
[4] Yamanaka, T., *J. Biol. Chem.*, **46** (10), 1289 (1959).
[5] Calvin, M., and Shibata, K., *Biochim. Biophys. Acta*, **17**, 1 (1955).
[6] Mizuhara, M., *Jinsen-Igaku* (in the press).

Pseudomonadaceae as a Source of Bacterial Contamination in Tissue Culture

The pleuro-pneumonia-like organisms cause considerable difficulty in tissue culture work, as many lines of cell cultures are contaminated with these organisms[1]. I have found that members of the Pseudomonadaceae could play a part as contaminants of tissue culture. It is well known that these bacteria are frequently a source of bacterial contamination in stored blood and blood derivatives[2].

I have isolated from apparently healthy tissue-cultures of human origin (human embryonic and baby kidneys and *KB* cells) a Gram-negative bacillus identified according to *Bergey's Manual of Determinative Bacteriology* (7th edit., 1957) as *Pseudomonas fragi*.

The main characteristics of the organism isolated were as follows:

P. fragi is a Gram-negative rod with a polar flagellum (0·5–1·0 × 0·75–4·0μ). It grows well on agar slants as white, glistening and butyrous colonies. In broth cultures a thin pellicle and a sediment are formed. The saccharolytic and proteolytic activities are poor; the organism produces acid from glucose, arabinose and galactose. Litmus milk is coagulated in 2–3 weeks, and it produces a characteristic 'strawberry' odour. On potato, *P. fragi* grows in raised, white colonies, which later become brown. It does not produce pigments.

The important observations for the tissue-culture work are: (1) *P. fragi* does not grow at 37° C., but remains viable at this temperature in the human embryonic and baby kidney tissue-culture for at least 30 days, and it can persist in *KB* cells through 65 passages made at three-day intervals without causing any visible damage to the cells; it grows at temperatures of 10°–30° C., the optimum for growth being 20° C. (2) It is a minute organism and it can pass through sintered glass filters (*G5*) commonly used for the preparation of tissue-culture media.

Because of these two characteristics it can remain undetected in contaminated tissue cultures if the sterility controls are not tested at room temperature (18°–20° C.). The organism is widespread in Nature, and can be encountered in air, soil and water. In my experience tissue-cultures were contaminated from tap water, and the organisms reached the tissue-culture media primarily through contaminated glassware and sintered-glass filters. It was detected by chance.

P. fragi can easily be detected in control tests for sterility. Cultures can be set up on ordinary bacteriological media incubated after plating at room temperature. The incubation period must be sufficient to permit growth of the organism. Direct growth from tissue cultures may be slower on account of the antibiotics added to the media. *P. fragi* grows in visible colonies from a tissue-culture medium containing 100 I.U. of penicillin and 100 μgm. of streptomycin in 48 hr.

A great number of saprophytes and plant parasites belong to the Pseudomonadaceae. Many members of this family have been isolated from water and I believe that, like *P. fragi* in my experiments, they could contaminate tissue cultures and remain there as latent contaminants.

M. Likar

University of Ljubljana,
Institute of Microbiology.

[1] Collier, L. H., *Nature*, **180**, 757 (1957).
[2] Bourgain, M., Bonnel, P. H., and Raby, C., *Ann. Inst. Pasteur*, **95**, 361 (1958).

BIOLOGY

Sun Navigation in Birds?

C. J. Pennycuick[1] has advanced a new hypothesis of Sun navigation in birds. The bird is supposed to measure the Sun's altitude and the rate of change of altitude and to compare these quantities with the respective memorized conditions at home.

The experimental evidence available does not agree with this theory in at least two major respects:

(1) The Sun's altitude: data have been presented[2] in which pigeons, following a phase-shift of their chronometers of 6 hr. clockwise, were released during the common light period of the artificially shifted and the natural day (which appears to be afternoon to the bird, but actually is forenoon). Only at one particular time of day (9.00 local time) do the altitudes of the anticipated and realized Sun with which the bird is confronted agree. All birds released before that time should, according to the hypothesis presented by Mr. Pennycuick, take their headings towards east to south-east, all birds released after that time towards north-west to north. This clearly was not the case. There was a deviation to the left, with reference to the headings of the controls, no matter what time and from which direction or distance the birds were released.

(2) In determining the rate of change of altitude either: (*a*) the bird has to be able to discriminate between a Sun going up and a Sun going down; or if not, (*b*) there would be an ambiguity during at least some portions of the day. Mr. Pennycuick does

not mention this point in his paper. An additional point of evidence against Sun navigation is implied by the data referred to under (1) if case (2a) should obtain for the rate of change of altitude. The birds should expect a decrease in altitude but will observe an increase in altitude. However, instead of eastward headings, as would be predicted by the hypothesis, there was a deviation to the left.

The first evidence of the orientational reaction of pigeons to a phase-shift of their chronometers[2] has, meanwhile, been confirmed by the results of experiments involving other degrees of phase-shift[3–5]. These results, however, were not yet generally available when Mr. Pennycuick's manuscript was submitted for publication.

This work is being supported by grant *G*9816 from the National Science Foundation to P. H. Klopfer.

Klaus Schmidt-Koenig

Department of Zoology,
Duke University,
Durham, North Carolina,
and
Max-Planck-Institut für Verhaltensphysiologie,
Wilhelmshaven,
Germany.

[1] *J. Exp. Biol.*, **37**, 573 (1960).
[2] Schmidt-Koenig, K., *Z. f. Tierpsychol.*, **15**, 301 (1958).
[3] Schmidt-Koenig, K., *Science*, **131**, 826 (1960).
[4] Schmidt-Koenig, K., *Cold Spring Harbor Symposia*, **25**, 389 (1961).
[5] Schmidt-Koenig, K., *Z. f. Tierpsychol.* (in the press).

(1) In the paper referred to, I followed Matthews[1] in assuming that the pigeon, on release, compares the Sun's altitude with the remembered altitude seen at the same time of day at home. In Schmidt-Koenig's 'clock-shifting' experiments the birds were accustomed to a light–dark rhythm advanced by 6 hr. in a light-proof room. Since they could not see the Sun during the training period, they clearly could not remember its altitude for subsequent comparison with the altitude observed on release. Hence these experiments shed no light on the possible use of altitudes for navigation in the way postulated, and neither the predictions stated nor any others based on altitude measurements would follow from my hypothesis.

(2) Schmidt-Koenig's experiments might have been interpreted in at least two ways by the pigeons.

(*a*) They may (as Schmidt-Koenig seems to assume) accept the 'shifted day', forgetting that the shift had been applied and assuming that they were still at home. On release in normal daylight they should then respond as though they had been taken a quarter of the way round the world, to the west. This is a very large displacement compared with any with which pigeons normally have to contend, and the release distances from home (5–5–100 km.) were insignificant by comparison. They would thus head east if a two-dimensional navigation system were being used.

If rate of change of altitude alone were being used (altitude being ruled out) they might respond to the gross difference which would occur—the Sun going up when, according to the time of day, it should be going down (Schmidt-Koenig gives no reason for his doubts as to whether the birds could distinguish opposite directions of movement). On the simple method of interpreting this, which is postulated in my paper, the birds would then orient themselves at right angles to the Sun's direction, with the Sun on their right. That they did not do so might be evidence against Sun navigation, but more likely it indicates that Schmidt-Koenig's interpretation of his experiment is not the correct one. The fact that behavioural rhythms became synchronized to the shifted day is no proof that the shift had been forgotten: the experiments in which pigeons were trained to take food in a particular direction referred to the Sun, also purporting to show that the clock had indeed been shifted, are also inconclusive, since there is no reason why the birds should associate this task with homing orientation—indeed, it was shown that most of them would not even allow for the Sun's motion during the day unless they were specifically trained to do so.

(*b*) The birds could alternatively have supposed that they had been taken for a few days to a place where the light–dark rhythm was advanced by 6 hr., and then brought back and released in the general neighbourhood of home (as had in fact happened). It is well known that pigeons will return to their old home after confinement in a distant place for much longer than the short training periods (4–10 days) used by Schmidt-Koenig, which amounts to the same thing. The experiment then becomes a test of ability to orient homeward after being denied sight of the Sun for a few days, during which the time-sense of the birds was subjected to severe stress. No specific effects would be predicted from this, but one might expect some general disorientation, giving increased scatter of direction of departure and reduced success in homing. These were observed.

It is true that the differences observed in directions of departure between experimentals and controls would not be predicted on my hypothesis, but Schmidt-Koenig has not explained these either. Probably the design of these experiments was too ambiguous to lead to any definite predictions.

Schmidt-Koenig's results are of great interest in that they confirm that pigeons have a time-sense, and that certain manifestations of it can be interfered with by applying shifted light–dark rhythms; but he is not justified in assuming that an experiment in which the bird is not allowed to see either the real Sun, or an artificial sun moving in a calculated path, will lead to results predictable from a theory of Sun navigation. In any event the time-shifts used (6–12 hr.) were unreasonably large: shifts of the order of 5–30 min. should produce effects comparable to those of the homing distances which have been used in previous experiments on pigeons.

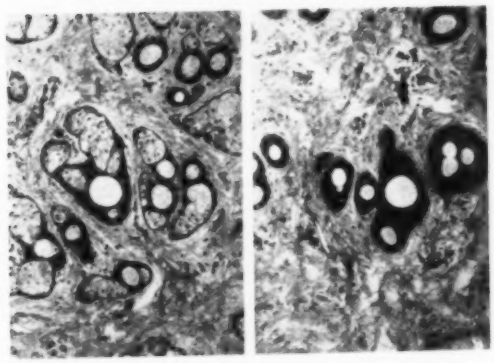
C. J. Pennycuick

Department of Zoology,
University of Cambridge.

[1] Matthews, G. V. T., *J. Exp. Biol.*, **30**, 243 (1953).

Bundles of Follicles in Adult Romney Ewes

Bundles of secondary follicles have been shown in the Karakul[1], Herdwick[2], Cheviot[2], Merino[3] and several other breeds[4] of sheep, and the formation of these bundles by the branching of follicles during their development has been demonstrated in the Karakul[1] and the Merino[3]. Branched primary (*P*) follicles have been described in the Merino and the Corriedale by Lyne[5], who also discussed his findings in relation to the fact that secondary/primary (*S*/*P*) ratios are normally determined from sections cut at the level of the sebaceous glands. At this level, branching follicles



(a) (b)

Fig. 1. A primary follicle bundle and a secondary follicle bundle; *a*, at the level of the sebaceous glands; *b*, above the level of the sebaceous glands, showing the coalescence of the root sheaths of the follicles. (× 100)

will not always be apparent so that some branching *P* follicles will be classified as secondary (*S*) follicles.

In recent work at Massey Agricultural College, skin samples were taken from the face (0·5 cm. trephine) and the mid-side (1 cm. trephine) of a flock of 111 2-year-old Romney ewes. Transverse skin sections were cut about the level of the sebaceous glands and stained with haematoxylin and eosin. During the determination of *S*/*P* ratios and follicle densities, branching *P* and *S* follicles were found in both mid-side and face samples.

It should be pointed out that the purpose of the work was not to determine whether branching follicles existed in the Romney breed; therefore, these observations are not based on complete serial sections of the follicles. However, in the light of Hardy and Lyne's[3] and Lyne's[5] work, it is reasonable to assume that if the root-sheaths of two follicles coalesce at a level above that of the sebaceous glands, then, nearer the skin surface, the lumens of the two follicles will do so as well (Fig. 1). Furthermore, as the branching follicles were observed mainly in those sections or part of sections cut higher than the level of the sebaceous glands, it is clear that the proportion of sheep showing branched follicles will depend on whether such sheep had sections cut at this level.

Branching *S* follicles were found in the mid-side samples of twenty-one of the 111 sheep (Fig. 1). Even within the limitations of the sections there appeared to be variations between sheep in the number of bundles of *S* follicles in the area sampled as the number of bundles varied from 1 to more than 80/π cm.^{2}. Again, within the limitations of the sections, the number of fibres/bundle varied from 2–5.

The occurrence of six branched *P* follicles in the mid-side sample of one sheep, which also showed marked *S* follicle branching, and the appearance of several more in the face samples of five sheep, was noted, again in those sections cut above the level of the sebaceous glands (Fig. 1).

In view of the work by Hardy and Lyne[3] and Lyne[5], it is unlikely that the branching follicles found in this study are anomalies as suggested by Auber and Ryder[2], although until the factors leading to the formation of these follicles have been determined, this must remain a possibility.

These findings suggest, therefore, that an investigation into the method and time of development and extent of branching of follicles in the Romney breed is needed. Such work, making use of Lyne's[5] suggested definitions of follicle types, could establish the importance of branching follicles to the type of fleece in this breed. Furthermore, the occurrence of bundles of both *P* and *S* follicles in the Romney and Merino breeds suggests the necessity for investigating the follicle populations of breeds of other wool types, as branching follicles may be a more common unit of the fleece than was previously thought.

I am indebted to Mr. P. G. Schinckel for confirming the identification of branching *P* and *S* follicles, Mr. G. A. Wickham and Mr. B. Thatcher for preparing and examining the sections and Dr. F. Cockrem for the use of his material and for helpful criticism.

This work was carried out with the aid of a grant by the New Zealand Wool Board.

D. F. G. Orwin

Sheep Husbandry Department,
Massey Agricultural College,
Palmerston North,
New Zealand.

[1] Tänzer, E., *Haut und Haar beim Karakul in rassenanalytischen Vergleich* (Otto Theile, Halle, Saale, 1926).
[2] Auber, L., and Ryder, M. L., *Proc. Intern. Wool Text. Res. Conf. Austral.*, **F**, 36 (1955).
[3] Hardy, M. H., and Lyne, A. G., *Austral. J. Biol. Sci.*, **9**, 423 (1956).
[4] Spöttel, W., and Tänzer, E., *Arch. Naturgesch.*, **89**, 1 (1923).
[5] Lyne, A. G., *Nature*, **179**, 825 (1957).

Independence of Temperature of the Rate of Ageing in *Drosophila subobscura*

The fact that in poikilotherms an increase in temperature reduces the life-span has naturally been taken as showing that the rates of ageing processes, like those of chemical reactions, are dependent on temperature. If so, an animal which is kept for an appreciable part of its life-span at a high temperature and is then transferred to a low temperature would be expected to die at a chronologically younger age than a similar animal kept continuously at the lower temperature. It has already been reported[1,2] that this expectation is not realized in the case of *D. subobscura*. Flies kept when young at 30° C. for periods equal to about half their expectation of life at that temperature and then transferred to 20° C. died at the same chronological age as did flies kept continuously at 20° C.

These results were interpreted, wrongly as we now think, as evidence that the causes of ageing at the two temperatures are different. But they can be explained in another way. Ageing processes may be defined as those processes occurring in individuals which render them more likely to die as they grow older, either from internal or external causes. It is convenient to describe the result of such processes as a decline in the 'vitality' of individuals as they grow older. It is supposed that the ageing process is not only the same at 20° C. and at 30° C., but also that its rate is the same at the two temperatures. Death occurs when the vitality of the individual falls below some threshold value, the level of which depends on the temperature at which the individual is living at the time, and which corresponds to the level of vitality necessary for survival at that temperature. Differences in longevity at different temperatures are then due, not to differences in the rate of the ageing process itself, but to different threshold-levels below which the vitality must not fall if life is to be maintained.

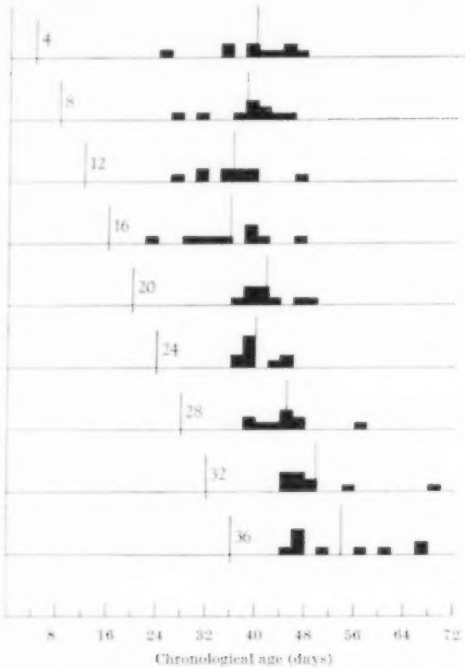


Fig. 1. Chronological ages at death of males kept for periods from 4 to 36 days at 20° C., and afterwards at 26° C.

This hypothesis would explain the earlier findings, since, provided that flies are transferred from the high to the low temperature before their vitality has fallen to the threshold-level corresponding to the higher temperature, their physiological state would be the same as that of flies of the same chronological age kept at the lower temperature. But there is another prediction from it which can easily be tested. Animals kept at a low temperature for a period equal to or greater than their expectation of life at some higher temperature should die immediately if transferred to that higher temperature. The experiment now to be described fully confirms this prediction, provided that the word "die" in the previous sentence is replaced by the phrase "start dying".

F_1 hybrid males between the *B* and *K* inbred lines were raised at the usual laboratory temperature of 20° C. A control group kept continuously at 20° C. had a mean longevity of 83·4 days. Groups of 10 males each were kept at 20° C. for periods varying from 4 to 36 days after emergence, and were then transferred to 26° C. and kept at that temperature until they died. The results are shown in Fig. 1. The first 6 groups to be transferred all died at the same chronological age of approximately 40 days, although the first group had a mean survival-time at 26° C. of 35·4 days, and the 6th group of only 16·2 days. This is exactly the result to be expected if the rate of ageing were independent of temperature. But the last four groups all had approximately the same survival time at 26° C. of about 16 days. This suggests that once the vitality has fallen below the threshold value appropriate to the temperature at which the flies are living, a second process is set in motion, a process we shall refer to as 'dying'. The threshold appropriate to 26° C. is reached at a chronological age of about 24 days, regardless of whether the flies have been living at 20° or at 26° C. If flies, aged 24 or more days, are transferred to 26° C. they start dying, a process which, at that temperature, is completed in about 16 days.

Similar results have been obtained in a number of experiments on both males and females, at temperatures ranging from 15° to 30° C. It has also been found that the 'dying' process is reversible. Males aged 12 or more days at 20° C. die after 3 or 4 days at 30° C. But males kept alternately for one day at 30° C. and for three days at 20° C. died at chronological ages varying from 53 to 85 days, after periods of from 8 to 17 days in all at 30° C. This shows that the changes occurring during the dying period at 30° C. can be repaired at 20° C.

The earlier experiments, together with those described here, lead to the following conclusions. The processes which ultimately result in the death of old flies can be divided into two stages, here called 'ageing' and 'dying'; these may correspond to the processes of induction and development suggested by Neary[3] from a study of mice. Ageing is an irreversible process the rate of which is roughly independent of temperature, at least from 15° to 30° C., and which leads to a continuous decline in the 'vitality' of the individual; by vitality is meant merely the capacity of the individual to withstand the various factors which may cause death. When the vitality falls below a certain threshold, a second process, that of dying, is set in motion. The level of this threshold is dependent on temperature, being lower at lower temperatures; it is differences in the threshold-level, and not in the rate of ageing, which are mainly responsible for differences in longevity at different temperatures. The dying process occurs at a rate which is dependent on temperature, and is terminated by death, but it can be reversed in individuals transferred to lower temperatures.

Jean M. Clarke
J. Maynard Smith

Department of Zoology,
University College,
London.

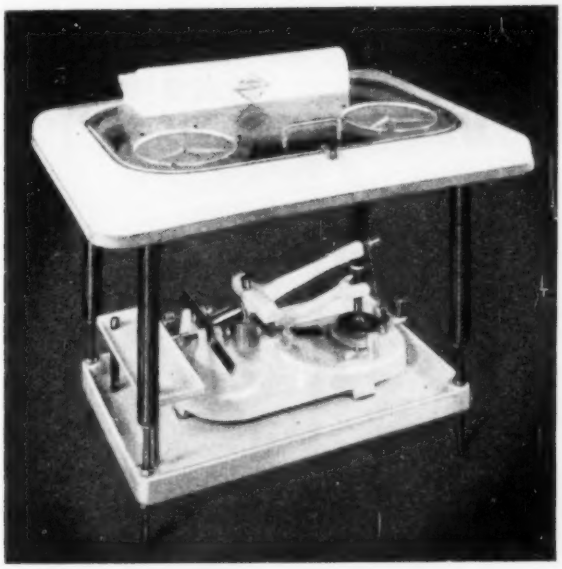
[1] Maynard Smith, J., *Nature*, **181**, 496 (1958).
[2] Maynard Smith, J., *J. Exp. Biol.*, **35**, 832 (1958).
[3] Neary, G. J., *Nature*, **187**, 10 (1960).

Further Evidence of Polar Movement of Nutrients in Plants

In two earlier papers I showed that there was good evidence for postulating polar rather than transverse movement of materials in plants[1a,b]. This conclusion was supported by later work on the movement of fluorescein in the xylem system[1c], of labelled carbon[2] and of labelled phosphorus[3]. The two last papers describe experiments which show that carbon-14 or phosphorus-32 when introduced on one side into the leaves or the roots respectively of plants pass freely and rapidly up to the tissues on that side, but do not move transversely across the plant.

The present communication describes some experiments which confirm the previous results, but which have the advantage that the tissues concerned were not mutilated by defoliation nor affected by the use of staining materials which are, to a greater or less extent, toxic to the living cells.

The technique is simple and can be carried out without the necessity for any precautions which may attend the use of radioactive materials. Further, the



When "FREEZING" is the only way

Certain techniques (for example: enzyme techniques, fluorescent antibody techniques, or where rapid diagnosis is required) prohibit the use of fixatives during the preparation of tissue sections for microscopy. Because freezing keeps sections fresh, unfixed sections of frozen tissue are in increasing demand. Although special freezing cabinets can be constructed to enclose the microtome, the CAMBRIDGE MICROTOME CRADLE has the great advantage that it can be used with certain commercially available deep-freeze cabinets already installed in many laboratories (without modifications). The bottom of the cabinet is still available for normal storage when the microtome is in position.

OPERATION OF MICROTOME.—Once in position, the microtome can be operated directly, without complicated mechanisms, through openings (rubber sealed) at the top. The effective design of this cradle has been confirmed by two years' routine operation of prototype models.

Cambridge

MICROTOME CRADLE
for deep freeze operation

MICROTOMES – *THE CAMBRIDGE RANGE*

FOR ROUTINE OPTICAL MICROSCOPY
The Cambridge Rocking Microtome

FOR LARGE SECTIONS
The Cambridge Rotary-Rocking Microtome

FOR ROUTINE ELECTRON MICROSCOPY
The Cambridge Fine-Section Microtome

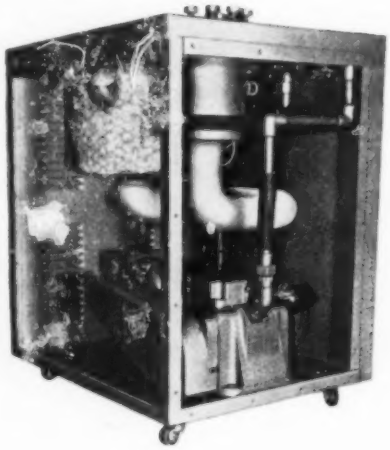
FOR ADVANCED WORK – SPECIALIST APPLICATIONS
The Cambridge Ultra-Microtome
(A. F. Huxley pattern)

Write for further information, quoting CAB/N. For future publications, ask for Mailing Form N/6/61.

CAMBRIDGE INSTRUMENT COMPANY LTD.
13 GROSVENOR PLACE · LONDON, S.W.1

RESIN IMPREGNATION

of wire-wound components under vacuum



N.G.N. new 'Resin-impregnating Plant' not only ensures better and far more thorough impregnation of all types of wire coils—its faster cycle of operation, coupled with carefully designed thermostatic control of vessels and pipework, plus full bore resin transfer valve, all combine to speed output while reducing costs.

Work chamber is evacuated to 1 micron Hg. to degas and dehydrate components which are then impregnated under a pressure of 80 lbs. p.s.i.

Surplus impregnant is completely recovered. Absolute reliability, both as regards thoroughness of impregnation and regular output is assured.

Enquiries for special plant to user requirements are especially welcome.

N.G.N. ELECTRICAL LIMITED
AVENUE PARADE, ACCRINGTON, LANCS. Tel: Accrington 35611-2

Secondhand Microscopes
We buy, sell or take in exchange
Clarkson's 338 High Holborn, W.C.1.
ESTABLISHED OVER A CENTURY
Opposite Gray's Inn Road. 'Phone: HOLborn 2149
INSTRUMENTS for HIRE

"GURR'S" *is the Registered Trade Mark of* **GEORGE T. GURR LTD.**
Since 1915 **"GURR'S"** brand of **MICROSCOPICAL STAINS** and Reagents has become world-famous.
If you want this world-famous brand specify **"GURR'S"** and refuse any other.
Ask for catalogues
GEORGE T. GURR LTD.
136-138 NEW KINGS ROAD, LONDON, N.W.6

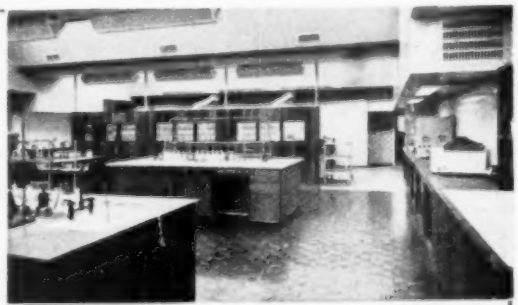
Scientific Circulations Ltd.
We have extensive stocks of Technical Journals, Periodicals and Textbooks. Special terms for Technical and Commercial Libraries. All Scientific and Technical publications purchased.
111, Eastbourne Mews, London, W.2
Telephone: AMBassador 6934

All communications regarding advertising in NATURE should be addressed to:
T. G. SCOTT & SON LTD.,
1 Clement's Inn, London, W.C.2

CYGNET meets the demands of science

The Associated Feed Manufacturers Research Laboratory, York Road, Belfast, is an excellent example of the top quality research accommodation now being provided for industry. Once again, Cygnet Laboratory Furniture provides the supreme craftsmanship and advanced design necessary for maximum efficiency.

Architects: Munce & Kennedy, A/ARIBA Architects & Consultant Engineers, University Street, Belfast, 7



CYGNET JOINERY LTD · HIGHER SWAN LANE · BOLTON · TEL: BOLTON 62121 (10 lines)

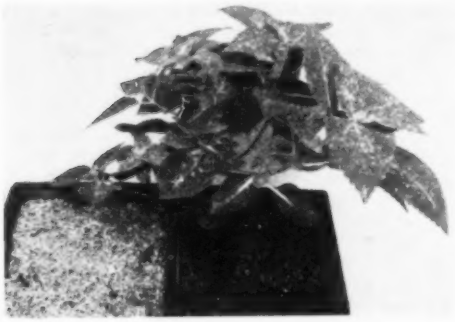


Fig. 1. Photograph of *Coleus* plant showing marked growth on the side of the plant with roots in soil

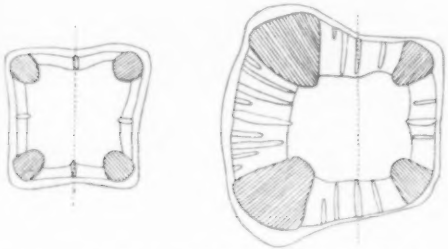


Fig. 2. Camera lucida drawing of section of *Coleus* stem (*a*) before experiment, (*b*) after three months. The dotted lines indicate the approximate position of the glass plate dividing the two media in which the cutting was grown

experiments were of comparatively long duration, showing that during a period of even three months the major portion of the metabolites move up and remain within the side on which they were originally absorbed or elaborated.

The experiments were set up as follows: young shoots of *Coleus* plants with 3–4 pairs of leaves were taken as cuttings and rooted in coarse sand without any added nutrients. After a couple of weeks or so, the end had developed a callus and adventitious rootlets had emerged. The end of the stem was then carefully slit with a razor by an incision up the middle at right angles to a pair of sides. It will be recalled that *Coleus* stems are square with pairs of opposite leaves inserted on the flat sides. In these stems there are four main vascular bundles, one at each corner of the stem. In the treated cuttings, therefore, there were two bundles on each side of the incision and the stems were symmetrical for all practical purposes.

The cuttings were then so placed on a sheet of glass dividing a wooden box into two compartments that each side of the stem and its adventitious roots was on one side of the sheet of glass. One compartment was filled with a rich loam, the other with a coarse sand without any added nutrients. Within a few days it was noted that the side of the plant above the soil was growing much more rapidly than that above the sand. The leaves on one side were much larger than the opposite members of the pairs, the axillary buds were developing into branches and the stem was much better grown on the soil side than on that over the sand. Clearly, the nutrients being absorbed from the soil were passing into and being retained by the tissues on that side of the plant.

At the end of three months a plant was photographed (Fig. 1), and all the leaves and axillary branches on the side above the soil and on that above the sand were removed. Though the alternate leaves on the other two sides also showed marked distortion — the side above the soil had grown much more than that above the sand, and similarly the axillary branches were correspondingly distorted — they were not taken into account for this measurement. Three sets of leaves and axillary branches were taken and dried at 100° C. The dry weights are given in Table 1.

Table 1

	Above soil	Above sand
Plant No. 1 (after 1 month)	1·07	0·54
Plant No. 2 (after 2 months)	1·85	0·41
Plant No. 3 (after 3 months)	7·54	1·57

Sections were made of the stem at an internode about the middle of the plant and Fig. 2 indicates the differences in the vascular tissues.

It will be noticed that the main vascular bundles on the corners of the stem above the soil had increased by about six times in area, while those above the sand had only doubled in cross-section after three months.

JOHN CALDWELL

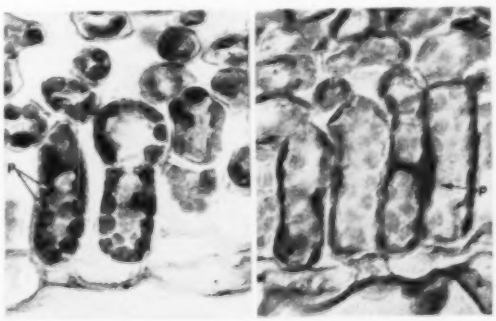
Department of Botany,
University of Exeter.

[1] Caldwell, J., (*a*) *Proc. Roy. Soc. Edin.*, **50** (1929); (*b*) *New Phytologist*, **29**, 1 (1930); (*c*) *ibid.*, **52**, 3 (1953).
[2] Jones, H., Martin, R. V., and Porter, H. K., *Ann. Bot.* (N.S.), **23**, 92 (1959).
[3] Rinne, R. W., and Langston, R. C., *Plant Phys.*, **35**, 2 (1960).

Staining Plastids in Chlorophyll-deficient Mutant Plants

Childers and McLennan[1] described collapsed, distorted palisade cells in a *viridis*-type chlorophyll mutant in alfalfa. A modification of Johansen's[2] quadruple stain was used for differentiating the plastids.

The technique is described here. Leaves were pre-fixed in Carnoy's fluid 6 : 2 : 2 for 30 sec., then fixed in Carpechenko's modification of Navashin's fluid. The tissue was dehydrated in Johansen's[3] tertiary butyl alcohol series. Sections were cut at 6μ and stained in the quadruple stain. The clearest differentiation was achieved by reducing the time in methyl violet to 7 min., while maintaining the time



(*A*) (*B*)

Fig. 1. Cross-sections of alfalfa leaves: (*A*) green leaf showing heavily stained plastids; (*B*) yellow leaf showing lightly stained but fully formed plastids. (× *c.* 575)

in fast green at 15 min. The nuclei were stained reddish-blue and the chloroplasts green. An advantage of this schedule is that de-staining is not critical and is accomplished by brief immersion in the de-staining solutions.

W. R. Childers

Genetics and Plant Breeding Research Institute,
Research Branch,
Canada Department Agriculture,
Ottawa.

[4] Childers, W. R., and McLennan, H. A., *Can. J. Bot.* (in the press).
[5] Johansen, D. A., *Plant Microtechnique* (McGraw-Hill, New York and London, 1940).

Nothofagus Pollen in the London Clay

The existence of southern families and genera with disjunct distributions, such as the Restionaceae and *Nothofagus*, has been used by many authors[1,2] as evidence supporting continental drift. Some[3] have stressed the importance of Antarctica as a Tertiary link between these presently disjunct areas without explicitly invoking the notion of drift. The presence of *Nothofagus* among the pollen and spores from Seymour Island, Antarctica[4], supports such a suggestion.

Bandulska[5] assigned a leaf from the British Tertiary to *Nothofagus*, but this isolated record received no further support. Recently, Erdtman[6] has recorded pollen of the Restionaceae from the British Early Tertiary. If supported by further evidence, these reports of tropical and southern hemisphere disjunct groups in the northern hemisphere temperate region might lead some to suggest that the Eurasian land mass may have served as a 'bridge' between the southern continents. A distinct Australian element exists among the genera represented by the fossil fruits and seeds of the London Clay; the proportion of Australian genera (40 per cent), although less than that of the genera of the Malay Islands (73 per cent), is nevertheless considerable[7].

In the course of an investigation of the pollen of the (Eocene) London Clay, I have now found, in addition to that of the Restionaceae and Proteaceae, *Nothofagus* pollen. The slides were sent to Prof. G. Erdtman of Stockholm for confirmation. He stated (personal communication) that he found it "impossible, at the present state of our knowledge, to avoid referring the grains to *Nothofagus*"; he regards the grains as more similar to certain recent *Nothofagus* pollen grains than to any other pollen grains so far known. The pollen came from the London Clay of Alum Bay, Isle of Wight, and the grains, which are 5- to 6-aperturate, compare favourably with those of *N. obliqua* of the *menziesii* group (Figs. 1–5). Harris[8] has shown that the aperture number in this group varies between 5–9. Although the exine of *Nothofagus* pollen has generally been considered to be undifferentiated, Prof. Erdtman has shown (personal communication and ref. 9) that the pollen grains in *N. obliqua* have delicate infrategillar bacula. The grains from the London Clay also have very short bacula between the nexine and the spinule-bearing tegillum.

The possibility of mis-identification has been ruled out because the pollen of *Nothofagus* is distinctive and characteristic. Its occurrence could be accounted for either by: (1) the pollen being transported long distances by sea (for example, from Australasia along the Tethys), or (2) its presence here in cooler upland areas. The first possibility is highly unlikely, although pollen has been known to cover considerable distances, while the second would be in accordance with what is implied by Bandulska's discovery.

In addition to members of disjunct groups dealt with above, I have also obtained pollen of temperate families, for example Betulaceae and Ulmaceae, from the London Clay. These families have not hitherto been recorded as megafossils at this horizon. Brett[10,11]

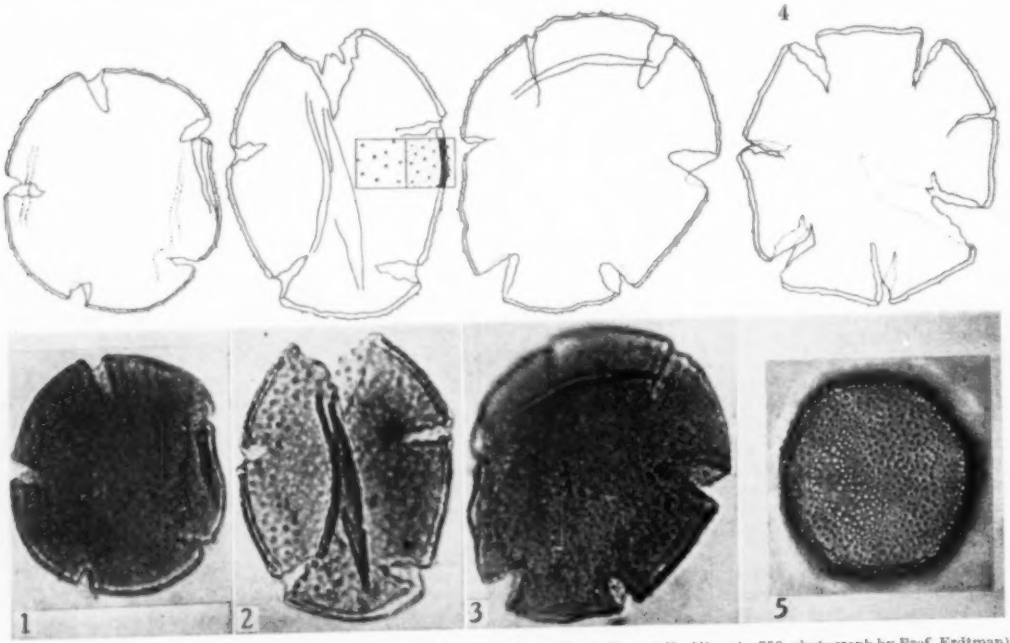


Fig. 1–3. Fossil *Nothofagus* (× 1,000). Fig. 4. Recent *N. obliqua* (× 1,000). Fig. 5. Recent *N. obliqua* (× 750, photograph by Prof. Erdtman)

reported two temperate families (Cercidiphyllaceae, Fagaceae) preserved as petrified wood. These records of pollen and wood thus indicate the existence of a more temperate element (possibly an upland one ?) in the British Eocene flora, which is under-represented in the fruits and seeds of the well-known London Clay flora. Evidently the fossil pollen (and to a lesser extent the fossil woods) represents a broader picture of the entire flora, and it may be that the fruits represent predominantly the swamp association. Comparable results have been reported by Gray[12], who recorded the pollen of a number of temperate genera in the Eocene flora of Alabama, believed, on the evidence of megafossils, to have been tropical.

MA KHIN SEIN

Botany Department,
University College,
London.

[1] Kryshtofovich, A. N., *New Phytol.*, **28**, 303 (1929).
[2] Good, R., *Nature*, **181**, 1763 (1958).
[3] Couper, R. A., *Proc. Roy. Soc. Lond.*, ser. B, **152**, 491 (1960).
[4] Cranwell, Lucy M., *Nature*, **184**, 1782 (1959).
[5] Bandulska, H., *J. Linn. Soc.*, **46**, 427 (1924).
[6] Erdtman, G., *Bot. Notiser*, **113**, 46 (1960).
[7] Reid, E. M., and Chandler, M. E. J., *The London Clay Flora* (British Museum Natural History, 1933).
[8] Harris, W. F., *New Zealand J. Sci. and Techn.*, **37**, No. 6, 731 (1956).
[9] Erdtman, G., *Bot. Notiser*, **113**, 285 (1960).
[10] Brett, D. W., *Ann. Mag. Nat. Hist.*, ser. 12, **9**, 657 (1956).
[11] Brett, D. W., *Palaeontology*, **3**, 86 (1960).
[12] Gray, Jane, *Science*, **132**, 808 (1960).

Proteolytic Activity of Crude Stem Extracts from Normal and Tumour Tissues of Plants

IN an effort to characterize more fully the tumorous tissue (crown-gall) induced in plants by *Agrobacterium tumefaciens*, the proteolytic content in the neoplastic tissues of several plants was investigated. Although a variety of enzymes have been found associated with crown-gall[1], no reports are available concerning proteolytic activities of such tissue extracts. Recent findings of increased proteolytic activity in mammalian neoplastic tissues[2,3] indicate a need for measuring the relative quantity of proteases in comparable plant tissues.

Greenhouse plants approximately 25 cm. high were inoculated by needle-puncture into stem tissue with 18-hr. agar-grown cultures of virulent or attenuated strains of *A. tumefaciens*. Tumours developing on tobacco (*Nicotiana tabacum* var. Wisconsin) were harvested approximately 5 wk. post-inoculation; on sunflower (*Helianthus annus* var. Mammoth Russian) and tomato (*Lycopersicon esculentum* var. Marglobe), 3 wk. after inoculation; and on beans (*Phaseolus vulgaris* var. Black Valentine) and *Kalanchoe daigremontiana*, approximately 6 wk. post-inoculation. Comparable areas on control stems which had been punctured under sterile conditions or inoculated with the avirulent strain *HBNV*6 were harvested at the same time, and constituted the 'normal' tissue to be compared with 'tumorous' tissue in later tests.

The excised tissue materials were ground in a Lourdes model *MM* tissue-homogenizer for 75 sec. at approximately 16,000 r.p.m., at a temperature of 1° C. A ratio of two parts buffer–potassium chloride solution to one part wet weight of plant tissue was used in the extractions for possible soluble fractions containing active proteolytic material. At *p*H 5·5, the buffer solution consisted of 0·1 *M* acetate–1·6 *M* potassium chloride[4]; at *p*H 7·5, it consisted of 0·1 *M* *tris*(hydroxymethyl)aminomethane - maleate – 1·6 *M* potassium chloride. The homogenized tissue was decanted into 50-ml. stainless steel tubes and centrifuged at −1° C. for 50 min. at approximately 20,000*g* in a Servall Superspeed refrigerated centrifuge. Supernatants were then adjusted to desired *p*H and kept at 1° C. or frozen at −17° C. until used in the digestion-reaction experiments. The Lowry[5] method was employed for all O.D. readings at 750 mμ (Spectronic 20). The Folin–Ciocalteu reagent was used in a dilution of 1-to-1, and a 1-to-5 dilution of supernatant from the TCA (trichloroacetic acid)-precipitated samples was used to eliminate interference in the development of the colorimetric reaction.

A digestion-reaction mixture consisting of 3 ml. buffer, 2 ml. demineralized water, 2 ml. substrate (urea-denatured bovine serum albumin, fraction V), and 1 ml. tissue extract was contained in a glass-stoppered reaction flask, and controlled at 35° C. for 18 hr. A 4-ml. aliquot was removed for the Lowry determination, and the remaining 4 ml. was employed as a final *p*H check on the reaction solution, which had previously been adjusted to the desired *p*H (buffer, substrate, and extract were all at this *p*H before addition to the reaction mixture). 'Zero' time systems containing exactly one-half the quantities of the respective digestion reaction mixtures served as control (blank) comparator systems for all readings at 750 mμ. A 5 per cent TCA solution was added to each 'zero' system immediately before incorporation of the tissue extract. Spontaneous hydrolysis controls for substrate and tissue extracts were tested with the other test systems. Since a low level of spontaneous hydrolysis prevailed, no corrections were made for the final O.D. readings of the digestion reaction.

The results in Table 1 indicate that, with the exceptions of sunflower and Kalanchoe stem tumour tissues, all other plants showed a much higher level of proteolytic activity in tumorous tissue than in their normal counterparts. The O.D. readings for tumorous tissues consistently reflected, in part, the proteolytic levels in normal tissues. For example, when normal tobacco tissue extracts yielded O.D. readings of 0·080 and 0·023, their respective tumour tissue extracts resulted in O.D. readings of 0·345 and 0·152. The total and protein nitrogen results appear

Table 1. COMPARISON OF NITROGEN CONTENT AND PROTEOLYTIC ACTIVITY OF CRUDE STEM EXTRACTS FROM VARIOUS PLANTS AT *p*H 5·5

Plant	Normal tissue*			Tumour tissue†		
	O.D.‡ 750 mμ	Total nitrogen§ mgm./ml.	Protein nitrogen‖ mgm./ml.	O.D. 750 mμ	Total nitrogen mgm./ml.	Protein nitrogen mgm./ml.
Tobacco	0·073¶	0·111	0·009	0·335¶	0·742	0·182
Tomato	0·070	0·142	0·023	0·210	0·415	0·052
Bean	0·085	0·349	0·051	0·222	1·383	0·289
Sunflower	0·035	—••	—	0·038	—	—
Kalanchoe	0·022	—	—	0·022	—	—
Kalanchoe††	0·028	0·047	0·013	0·111	0·214	0·030

* A mixture of sterilely punctured tissues and tissues inoculated with attenuated strain *HBNV*6 of *A. tumefaciens*.
† A composite of extracts from tissues inoculated with *A. tumefaciens* strains *B6*, *A6K1* and 11156 (*ATCC*).
‡ Optical density readings based on aliquots from an 18-hr. digestion at 35° C.
§ Micro-Kjeldahl.
‖ Method of Markham (ref. 8).
¶ Extracts heated to 75° C. for 10 min. inactivated the proteolytic activity.
•• Not done.
†† Leaf tissue.
Bacteriological examinations of the reaction mixtures at termination of digestion period indicated no gross contamination.

to correspond to the relative proteolytic activities of normal and tumour tissue extracts from a given plant. However, it should be noted that no absolute quantitative relationship exists between O.D. readings and nitrogen contents. Until such time as one can evaluate the relative ratios between non-enzymatic nitrogen (nucleic acid, nucleo-protein, etc.) and proteolytic-enzyme-nitrogen, the relationship can only serve as an indicator of higher or lower proteolytic activity within a single set of stem extracts.

Reports of protease activity in leaf tissue of tobacco[6] and more pronounced proteolytic activity in leaf than in stem or root tissue in soybean[7] prompted a study of the relative proteolytic activity in leaf-tumour and normal tissues. Kalanchoe (Table 1) was selected because of its low level of activity in stem-tissue extracts. The results indicate a definitely higher level of activity in leaf tumour than in the stem tumour, although no apparent difference seems to exist in the respective normal tissues. Experiments are now in progress which are intended to evaluate the proteolytic relationship of leaf to stem tumour extracts of all the plants used in this work.

In conjunction with the results in Table 1, there are three additional observations: although the recorded results are based on freshly extracted material, extracts of tobacco frozen for 64 days showed no diminution in proteolytic potency. Secondly, activators such as BAL (2,3 dimercaptopropanol) and cysteine-hydrochloride actually decreased the proteolytic response of both normal and tumour tissue extracts when incorporated into the digestion-reaction mixture. Weil *et al.*[8] reported a comparable finding for proteases of certain aerobic bacteria with cysteine. Lastly, preliminary studies with stem extracts from tobacco and tomato at *p*H ranges from 2·5–8·5 indicate that the best range for proteolytic activity of the crude extracts lies at approximately 4·5. Additional work with frozen extracts, extended *p*H ranges for the best activities, and the effect of activators is now in progress.

The majority of our initial stem work was carried out at *p*H 5·5. Later experiments at alkaline *p*H ranges indicated a low level of activity. It was thought advisable to find what relationship exists between the extracting *p*H and the digestion *p*H. The results in Table 2 indicate clearly that, although a tissue may be extracted at *p*H 7·5 (low activity), it still possesses an active proteolytic principle, which can be demonstrated by adjusting this extract to *p*H 5·5 (high activity) and carrying out the digestion at this *p*H. Conversely, if an active extract at *p*H 5·5 is adjusted to *p*H 7·5 and the digestion reaction conducted at this latter *p*H, there will be a very low level of proteolytic activity.

In conclusion, it can be noted that crude extracts from tumorous stem tissue of tobacco, tomato and bean possess greater proteolytic activity than their respective normal tissues; that no apparent difference in proteolytic activity between tumour and normal stem extracts from sunflower and Kalanchoe can be demonstrated; and that with an acid *p*H (5·5) of digestion there is greater proteolytic activity than with alkaline conditions.

Table 2. Effect of Reciprocal Adjustment of *p*H on Proteolytic Activity of Extracts from Normal and Tumorous Tobacco Stem Tissue

*p*H of extraction	*p*H of digestion reaction†	O.D.* — 750 mμ	
		Normal tissue	Tumour tissue
5·5	5·5	0·088	0·390
5·5	7·5	0·005	0·010
7·5	7·5	0·010	0·026
7·5	5·5	0·045	0·270

* Digestion at 35° C., for 18 hr.
† *p*H of extracts adjusted before addition to the digestion-reaction system.

We thank Miss Dorothea Williamson for the nitrogen determinations, and Drs. A. C. Braun and A. C. Hildebrandt for the *B6* and *A6K1* strains of *A. tumefaciens*.

This work was supported by grants from the United States Public Health Service, National Institutes of Health (*C*-4624), and from an Institutional grant (951–716*C*) by the American Cancer Society.

C. Gainor
F. D. Crisley

Department of Biological Sciences,
University of Pittsburgh,
Pittsburgh, Pennsylvania.

[1] Klein, R. M., and Link, G. K. K., *Quart. Rev. Biol.*, **30**, 207 (1955).
[2] Libenson, L., and Jena, M., *Cancer*, **10**, 1004 (1957).
[3] Sylven, B., and Bois, I., *Cancer Res.*, **20**, 831 (1960).
[4] Martin, C. J., and Axelrod, A. E., *J. Biol. Chem.*, **224**, 309 (1957).
[5] Lowry, O. H., Rosebrough, N. J., Farr, A. L., and Randall, R. J., *J. Biol. Chem.*, **193**, 265 (1951).
[6] Tracey, M. V., *Biochem. J.*, **42**, 281 (1948).
[7] Frieberg, S. R., *Science*, **115**, 674 (1952).
[8] Markham, R., *Biochem. J.*, **36**, 790 (1942).
[9] Weil, L., Kocholaty, W., and Smith, L. D., *Biochem. J.*, **33**, 893 (1939).

Fungal Colonization of a Developing Salt Marsh

During work on fungal colonization of a developing salt marsh at Gibraltar Point, Lincolnshire, National Grid reference *TF*555576 (a preliminary account of which has been given[1]), the rhizosphere populations were used as indicators of changing fungal populations in the different areas of colonization by phanerogams. The number of fungal isolations from mud uncolonized by higher plants and from the rhizospheres of the common salt marsh plants are given in Table 1. Five Petri dishes per sampling site were inoculated with approximately 0·5 gm. fresh mud each month that samples were collected. This mud was covered with mud extract agar[2] (Warcup soil plate technique[3]) using larger inocula than recommended in the original technique to compensate for the paucity of fungi in the muds as compared with normal soils.

The percentage differences from bare mud have been calculated to illustrate the increased fungal coloniza-

Table 1. Numbers of Fungal Isolations from Different Sampling Sites

	Sampling site	No. of isolations	No. of samples	Average isolations per sample	Percentage difference from bare mud†
	Bare mud	148	12	12·3	—
A	Low *Salicornia**	162	12	13·5	+9·8
	Lower *Spartina*	102	11	9·3	−24·4
B	Middle *Salicornia*	111	8	13·9	+13·0
	Upper *Spartina*	97	10	9·7	−21·1
C	High *Salicornia*	104	8	13·0	+5·7
	Halimione	90	6	15·0	+22·0
	Suaeda	113	7	16·1	+30·9
	Puccinellia	100	6	16·6	+35·0

* Plants grouped under *A* were sampled at the same horizontal level on the marsh: this applies equally to *B* and *C*.
† Percentage of difference = difference between number of fungi isolated from rhizospheres and from bare mud, calculated as a percentage of the bare mud isolations.

tion up the shore. These changes may reflect the greater amount of organic matter present as a result of increasing cover by higher plants, and may also reflect the reduced periods of inundation by the sea.

The exceptions to the general increase call for comment. The high *Salicornia* zone shows a smaller difference from bare mud than the lower *Salicornia* zone, and this is the more striking when compared with the results obtained from *Halimione*, *Suaeda* and *Puccinellia* at the same level. This may be a reflexion of the stunted growth of the high *Salicornia* plants.

The two *Spartina* sites show a marked decrease in numbers of isolations compared with bare mud, and again this is emphasized by the increases obtained from the rhizospheres of nearby *Salicornia* plants. Depression in fungal numbers under *Spartina* may be a concomitant of the growth habit of these plants: many, particularly those in the lower zone, grow in water-filled depressions where conditions frequently lead to the formation of black muds by the activities of sulphate-reducing and possibly other sulphide-producing bacteria. Similar black muds are also found in the upper *Spartina* zone, where there may be interpolated sandy horizons. A preliminary comparison of non-reduced and reduced *Spartina* rhizosphere muds indicates that it is the condition of the reduced muds (possibly the low Eh, or the toxic effect of accumulated sulphides) and not any inhibitory effect of the *Spartina* which causes the depression in fungal numbers.

Physiological aspects of this work are now being studied: ecological aspects are being prepared for publication.

Thanks are due to Prof. C. G. C. Chesters for his help in the preparation of this communication, and to Mrs. M. Turner and Mr. T. R. G. Gray for many fruitful discussions.

G. J. F. Pugh

Department of Botany,
University of Nottingham.

[1] Pugh, G. J. F., in *The Ecology of Soil Fungi* (University of Liverpool Press, 1960).
[2] Turner, M., and Pugh, G. J. F., *Trans. Brit. Mycol. Soc.* (in the press).
[3] Warcup, J., *Nature*, **166**, 117 (1950).

Molybdenum and the Fixation of Nitrogen in *Myrica* Root Nodules

We have shown elsewhere[1] that nodulated plants of *Casuarina* and *Alnus*, grown under conditions which entail dependence on the fixation of elemental nitrogen, develop symptoms of severe nitrogen deficiency when deprived of molybdenum; this and other evidence obtained is wholly consistent with the view that, as in other biological nitrogen-fixing systems, molybdenum fulfils an essential role in the fixation proceeding in the root nodules of these non-legumes.

Work has now been extended to a third genus, *Myrica*. Young plants of *M. gale*, from seed sown in peat (experiment I) or purified sand (experiment II), were transplanted at the two-leaf stage into water-culture in 'Pyrex' beakers, the culture solution being prepared from reagents purified from molybdenum at the Long Ashton Research Station. All elements known to be essential were provided, except that no combined nitrogen was supplied (apart from an initial addition of 0·4 mgm. ammonium–nitrogen per plant in experiment I and 2·0 mgm. per plant in experiment II, to sustain the plants over the period of nodule formation), while molybdenum was omitted from certain cultures. Nodulation was secured by application to the root systems of an inoculum prepared by crushing nodules from field plants of *M. gale* in water. The plants were grown by daylight in the greenhouses of the Botany Department, University of Glasgow; other details of procedure were as described elsewhere[1].

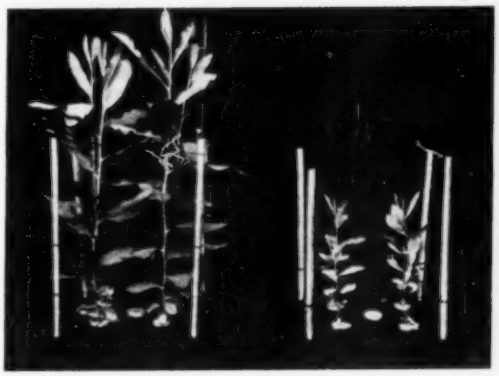


Fig. 1. Nodulated plants of *Myrica gale* after 12 weeks growth in water culture with (left) and without molybdenum supplied. (× 3/16). Photograph by Mr. R. Cowper

Nodules appeared some 2 wk. after inoculation, followed, after a further interval, by the commencement of vigorous growth in the plants supplied with molybdenum, indicative of the onset of fixation of nitrogen in the nodules. The plants not supplied with molybdenum lagged behind in their growth and developed symptoms of nitrogen deficiency; they were much reduced in stature and had small, pale-green leaves. Fig. 1 illustrates the disparity between the two types of plant at harvest after twelve weeks growth in water culture, while results based on the examination of some twenty plants in each treatment are provided in Table 1.

The results confirm the poor growth of the plants deprived of molybdenum and their deficiency in nitrogen. Fixation of nitrogen per plant, calculated by deducting from the total nitrogen per plant (Table 1) the mean nitrogen content of non-nodulated control plants, amounted to 15·0 mgm. (+Mo) and 1·5 mgm. (−Mo) in experiment I, and 13·7 mgm. (+Mo) and

Table 1

	Treatment	Mean dry weight per plant, mgm.*	Mean per cent nitrogen in plant dry matter	Mean total nitrogen per plant, mgm.	Molybdenum, p.p.m. in dry matter		
					Nodules	Shoot	Roots
Experiment I	+Mo	557	2·76	15·3	78·61	31·10	5·83
	−Mo	97	1·59	1·5	1·58	0·16	2·71
Experiment II	+Mo	510	2·92	14·9	273·70	52·34	33·94
	−Mo	150	1·95	2·9	0·93	0·18	0·97

* Statistical analysis of the dry weight data showed the differences between treatments to be significant at $P = 0{\cdot}01$.

1·8 mgm. (−Mo) in experiment II. Relative to plant size, nodulation was actually better in the plants deprived of molybdenum, since nodule dry weight amounted to 14·4 per cent of whole plant dry weight in their case, but only to 7·1 per cent where molybdenum was supplied (mean values for the two experiments). Where molybdenum was provided, 383 mgm. of nitrogen was fixed per gm. of nodule dry matter formed, whereas the corresponding value for the molybdenum-deficient plants was only 83 mgm.; thus with molybdenum available, the nodule tissues were nearly five times more effective in fixation. Certain plants, deprived initially of molybdenum, were supplied with the element at an intermediate stage and showed obvious benefit within a few days.

The results in Table 1 also indicate the high accumulative capacity of the nodules for molybdenum. The higher molybdenum content, particularly in nodules and roots, shown in the plus-molybdenum plants of experiment II is possibly related to the circumstance that this experiment was conducted during the most favourable period climatically (May–August). In both experiments 0·05 p.p.m. of molybdenum was supplied in the culture solution where appropriate, some 17 per cent of the total supplied being absorbed by the plants in experiment I and 34 per cent in experiment II. Of the total molybdenum present in the plants at harvest, 24 per cent was in the nodules when molybdenum was supplied and 32 per cent when it was not.

The above results closely resemble those obtained in experiments with *Casuarina* and *Alnus*[1], and point to a special role for molybdenum in fixation in *Myrica* nodules also. A further finding of possible significance is that the two samples of field nodules of *M. gale* examined in this work proved to have molybdenum contents of 3·04 and 1·40 p.p.m. in the dry matter respectively; the latter value is of the same order as those for the nodules of plants cultured without molybdenum which fixed little nitrogen.

Technical assistance was provided by Miss K. McCormick and Mr. D. James.

G. Bond

Botany Department,
The University,
Glasgow.

E. J. Hewitt

Long Ashton Research Station,
The University,
Bristol.

[1] Hewitt, E. J., and Bond, G., *Plant and Soil* (in the press).

Gibberellin Action on Growth of Seedlings in the Absence of Photosynthesis

A major effect of gibberellins on growing seedlings is often an increased dry weight, especially in the shoots growing in the light[1]. These and other observations have frequently led to suggestions that this particular gibberellin effect may be related to an increased photosynthetic carbon-fixation. We have found, however, that in light-grown seedlings that are prevented (by darkness) from performing photosynthesis, gibberellic acid can increase their dry weight over water-control seedlings. The effect of gibberellic acid in these experiments thus cannot be attributed to either direct or indirect actions on photosynthetic fixation.

Wheat, *Triticum vulgare*, var. Thorne, was germinated on 'Lucite' bars wrapped with moist paper towels in covered germinating dishes at 23 ± 1° C. during a 16-hr. day (~500 ft. candles white light) and 17·5 ± 1° C. during the night. Four days after sowing the seedlings were transferred to darkness permanently with or without gibberellic acid. Plants, the heights of which differed by less than 2 mm., were paired so that within each experiment the population receiving treatment with gibberellic acid was comparable with the corresponding water controls. Seedlings were sown on two pieces of Whatman No. 1 filter paper moistened with 25 ml. of solutions, all at about *p*H 5·7, in 9-cm. Petri dishes. The dishes were kept in light-proof wooden boxes in the same growth-room. The plants remained in complete darkness except for a few moments of low-intensity green light while watering. After 4 days in darkness the shoots and roots were detached from the scutella, washed, and dried in an oven at 60° C. at least overnight. All plant material from a given experiment was dried for 3 days and ground in batches to a fine powder in a Wiley Mill using a 40-mesh screen. Within each batch the ground material thus was mixed so that portions removed for analysis were homogeneous and representative of the entire group of shoots or roots after each treatment (treated with gibberellic acid or control). Total carbon was determined by a modified Pregl method[2]. Soluble carbohydrate was extracted in boiling water and analysed by the anthrone method[3]. Total nitrogen was determined by a micro-Dumas method[2]. Protein was determined by the method of Lowry *et al.*[4]. In all these analyses duplicate samples never differed by more than a few per cent.

The dry weights of 8-day-old seedlings which had been transferred to darkness with or without gibberellic acid when 4 days old are listed in Table 1. In all experiments the plants weighed approximately two to three times more at 8 days than they did at 4 days. The treated seedlings, compared to control seedlings, showed typical gibberellin effects: greater dry weight of the shoot, less dry weight of the root system, and in most cases a greater dry weight of the whole plant. Uptake of the gibberellic acid itself could not have been sufficient to cause these differences in dry weight. Treatment with sucrose during the 4 days in darkness did not significantly alter the results.

Chemical analyses of dried shoots and roots from one experiment are given in Table 2. The increases in total carbon, soluble carbohydrate, total nitrogen, and protein in the shoots treated with gibberellic acid

Table 1. Dry Weight of Wheat Seedlings treated with Gibberellic Acid in Darkness. Seedlings were 4 days old when treated, 8 days old when dried

Exp.	Sucrose concentration (per cent)	Concentration of acid (*M*)	No. of plants	Dry weight per plant (mgm.)		
				Shoot	Roots	Total
1	0	0	44	8·76	4·87	13·63
		3×10^{-5}	44	9·67	4·44	14·11
2A	0	0	48	7·76	4·92	12·68
		3×10^{-5}	48	9·07	4·69	13·76
2B	1	0	48	8·25	5·10	13·35
		3×10^{-5}	48	8·95	4·70	13·65
2C	2	0	48	7·25	4·73	11·98
		3×10^{-5}	48	8·51	4·71	13·22
3	0	0	80	7·17	4·95	12·12
		3×10^{-5}	80	7·81	4·24	12·05

Table 2. Chemical Analysis of Seedlings treated with Gibberellic Acid in Darkness*

Analysis	Content and concentration	Shoot		Root system		Total	
		Water controls	Treated	Water controls	Treated	Water controls	Treated
Total carbon	mgm./plant	3·34	3·80	2·17	2·01	5·51	5·81
	percentage of dry weight	43·1	41·9	44·1	42·9	43·5	42·2
Soluble (boiling water) carbohydrate	mgm./plant	1·88	2·02	1·03	0·94	2·91	2·96
	percentage of dry weight	24·3	22·3	21·0	20·0	22·9	21·5
Total nitrogen	mgm./plant	0·307	0·377	0·142	0·127	0·449	0·504
	percentage of dry weight	3·96	4·16	2·88	2·71	3·54	3·66
Protein	mgm./plant	0·98	1·09	0·62	0·61	1·60	1·70
	percentage of dry weight	12·6	12·0	12·6	13·0	12·6	12·4

* Analyses were performed on finely ground dried material from plants in exp. 2A in Table 1

were approximately proportional to the dry weight increase.

Since the plants were not exposed to light during the time they were in contact with gibberellic acid, there could be no photosynthesis while the acid was increasing the dry weights. The gibberellic acid effects therefore could not be related in any way to photosynthetic fixation. The endosperm reserves plus photosynthesis that occurred before treatment with gibberellic acid were sufficient to produce the dry weight increases, since the addition of sucrose did not seem to greatly alter the results. The proportional increases in total carbon, soluble carbohydrate, total nitrogen, and protein suggest a general acceleration of growth under conditions in which neither carbon nor nitrogen is deficient. This effect of gibberellic acid treatment in darkness is on seedling growth proper, and has no relation to any action of the acid in breaking dormancy, because the plants were not treated with the acid until 4 days after sowing, when they were several cm. high.

These results are consistent with the finding that gibberellic acid does not increase directly either the rate or the pattern of photosynthetic $^{14}CO_2$ fixation in short-time experiments[5]. They also weaken suggestions that dry weight increases from treatment with gibberellic acid must necessarily be attributed to indirect effects on photosynthetic fixation. The fact that leaves treated in the light do not increase in chlorophyll content even though they increase in area[6] is further evidence against the theory that fixation is increased because of a greater photosynthetic area[1,7]. In his argument that fixation is increased by an accelerated mobilization of photosynthate, Alvim[8] apparently has equated photosynthesis with 'net assimilation rate'. Although we do not question that gibberellic acid can increase net assimilation, we do question that such increased net assimilation must necessarily be related to an increased photosynthetic fixation. Photosynthesis is but a part of the complex of many anabolic and catabolic processes which together determine net assimilation. Thus we are inclined to believe that an increase in dry-matter content in plants treated with gibberellic acid in light does not necessarily result from either direct or indirect increases in photosynthetic fixation, but can be attributed to altered utilization of photosynthate and other metabolites, regardless of their origin. Coulombe and Paquin[9] reported transient changes in transpiration as well as both respiratory and photosynthetic net gaseous exchanges of carbon dioxide after treatment of tomato leaves with gibberellic acid. To our knowledge, however, no one has demonstrated that gibberellin treatment can increase photosynthetic fixation, that is, the light-dependent reduction of carbon dioxide in green tissues. Products derived from photosynthesis undoubtedly are involved in the metabolic processes which underlie the response to gibberellic acid of light-grown plants, just as they are involved in other aspects of plant metabolism. But at the present time it seems doubtful whether gibberellic acid generally increases shoot dry weight by increasing photosynthetic fixation.

Alan H. Haber
William L. Carrier
N. Jean Enochs*

Biology Division,
Oak Ridge National Laboratory,†
Oak Ridge, Tennessee.

* Biology student trainee from David Lipscomb College, Nashville, Tennessee.

† Operated by Union Carbide Nuclear Co. for the U.S. Atomic Energy Commission.

[1] Brian, P. W., *Biol. Rev.*, **34**, 37 (1959).
[2] Strouts, C. R. N., Gilfillan, J. H., and Wilson, H. N. (eds.), *Analytical Chemistry*, **1** (Clarendon Press, Oxford, 1955).
[3] Loewus, F. A., *Anal. Chem.*, **24**, 219 (1952).
[4] Lowry, O. H., Rosebrough, N. J., Farr, A. L., and Randall, R. J., *J. Biol. Chem.*, **193**, 265 (1951).
[5] Haber, A. H., and Tolbert, N. E., *Plant Physiol.*, **32**, 152 (1957).
[6] Wolf, F. T., and Haber, A. H., *Nature*, **186**, 217 (1960).
[7] Stowe, B. B., and Yamaki, T., *Science*, **129**, 807 (1959).
[8] Alvim, P. De T., *Plant Physiol.*, **35**, 285 (1960).
[9] Coulombe, L. J., and Paquin, R., *Canad. J. Botany*, **37**, 897 (1959).

GENETICS

Non-disjunction of the Sex-chromosomes in the Male of *Drosophila melanogaster*

The discovery that certain human abnormalities have a chromosomal basis has stimulated renewed interest in the phenomenon of non-disjunction. Theoretically, non-disjunction may occur in both the male and female germ cells at either the first or second meiotic division and may give rise to a considerable variety of non-disjunctional types in the progeny. In practice, only non-disjunction occurring at the first meiotic division in oocytes has so far been studied in *Drosophila*. The present communication reports the occurrence of spontaneous non-disjunction of the sex-chromosomes in *Drosophila* males.

The scheme used involves *brown-variegated*, bw^{VA}, an inversion originally obtained by H. J. Muller in the second chromosome which, in combination with the sex-linked gene *vermilion*, *v*, produces a characteristic yellow eye colour. This position effect of bw^{VA} is suppressed by the presence of an extra *Y*-chromosome, so that males of the genotype *XYY* and females of the genotype *XXY* exhibit the bright red eye colour normally associated with *v*. With the aid of this scheme, a search was made for the presence

of *XXY* and *XYY* individuals in the progeny of normal *XY* males and *XX* females. Markers on the paternal and maternal *X*-chromosomes were used to decide whether non-disjunction had occurred in the father or the mother. The presence of an additional *Y* in the exceptional individuals was confirmed by progeny tests.

In addition to the already known types of non-disjunction, the following new ones occurred:

(1) *XXY* females with one paternal and one maternal *X*, which thus must have arisen through fertilization of a disjunctional egg by a non-disjunctional *XY* spermatozoon.

(2) *XYY* males with a maternal *X*. These probably arose through non-disjunction at the second meiotic division in the male. An alternative interpretation cannot be excluded, however. Lamy[1] found a small proportion of patroclinous *XXY* daughters with detached *X*'s among the progeny of attached-*X* females and attributed their occurrence to equational doubling of the *X*-chromosome in the sperm. She did not consider the possibility of non-disjunction at the second meiotic division. The frequency of *XXY* females in her experiments was considerably higher than that of *XYY* males in those reported here. If Lima-de-Faria's[2] observation that, in grasshopper chromosomes, euchromatin divides more rapidly than heterochromatin, should apply also to the chromosomes of *Drosophila*, equational doubling of the *Y* may take place very rarely or never.

The results obtained in this preliminary observation do not yet permit accurate quantitative estimates of the frequencies with which the various types of non-disjunction take place. The approximate frequencies, however, appear to be of the order of 0·01 per cent for type (1) and 0·004 per cent for type (2). The accurate frequencies as well as a possible influence of parental age will be determined in a more comprehensive investigation.

P. J. Kelsall

Institute of Animal Genetics,
University of Edinburgh.

[1] Lamy, R., *Drosophila Information Service*, **23**, 91 (1948).
[2] Lima-de-Faria, A., *Science*, **130**, 503 (1959).

Determining Mating Type in *Neurospora* without Crossing Tests

Strains of *Neurospora crassa* belonging to either *A* or *a* mating type are morphologically indistinguishable. Mating type determinations are usually made by observing whether perithecia occur after crossing strains of unknown mating type to *A* and *a* tester strains. The tests are usually run either in two series of culture tubes or in pairs of Petri dishes. The use of tester strains on a large scale, however, may become laborious, ambiguous tests have to be re-run, and infertility sometimes confuses the results.

An alternative method which has been found useful for sex-testing numerous progeny from crosses employs a strain unable to grow on complete medium at elevated temperatures due to a mutant allele very closely linked to the mating-type locus. This strain, *unknown* (55701) (*un*), grows slowly on minimal medium at 25° C., but is stimulated by addition of acetate. At 35° C., however, no growth occurs on any medium yet tried[1]. *un* has shown very close linkage with mating type in tetrad analysis, no recombination between these two loci having as yet been obtained (Table 1). Since no recombination has been obtained, all the derived strains of *un* at present known are of the same mating type, *a*, as the one in which this mutation was originally induced[2].

Table 1. Crosses showing Linkage of *un*(55701) to *sex*

Cross	No. of asci	Recombination between *un* and *sex**
1A × *un a*	38	None (4)
cis A × *un a*	16	None (4)
pyr(68902) *A* × *un a*	22	None (4)
74A × *un ad-5 a*	94	None
ad-5 A × *un a*	21	None
frost A × *un a*	40	None
frost leu-3 A × *un ad-5 a*	56	None
leu-3 A × *un a*	18	None
leu-3 A × *un ad-5 a*	30	None
Total	335	

* Fiducial upper limit of recombination frequency between *un* and *sex* at the 5 per cent level is 0·011.

In practice, the *un* allele is incorporated into one of two parental stocks prior to crossing these two stocks with each other. Segregants isolated from the cross either by dissection or by sorbose plating[3] are placed in culture tubes of complete medium and incubated at 25° C. until initial growth verifies isolate viability. Complete media should include 333 mgm. sodium acetate per litre to stimulate growth of *un* at 25° C. As soon as initial growth occurs the tubes are transferred to 35° C. for 24–48 hr. Tubes should be placed at 35° C. only after initial growth is observed, because germinating *un* ascopores or incipient *un* mycelial transfers die if held excessively at 35° C.

The tubes which show no further growth at 35° C. contain the *un* allele and are, with high probability, of the same mating type as the *un* parent used in the cross. The tubes showing completed growth at 35° C. contain the *un*$^+$ allele and are, with high probability, of opposite mating type. All tubes are then returned to 25° C. where the *un* isolates will complete growth. No crossing tests and no subculturing are necessary.

Alternatively, scoring may be done exclusively at 25° C. by omitting acetate from the medium. In this case the *un* allele is readily distinguishable by markedly slow growth, provided no other segregating markers give sub-wild growth-rates.

The *un* segregation method is especially convenient when large numbers of segregants have to be scored for mating type. Investigations in which chromosomal aberrations such as translocations are being followed or where the mating type locus itself, for example, may require the sex-testing of numerous progeny. In such cases it seems more efficient to incorporate *un* into a parental stock and follow *un* segregation by means of temperature variation or slow growth-rate than to cross each isolate to two tester strains.

The accuracy of the method depends on the strength of the linkage between the *un* and *sex* loci. So long as this linkage holds, segregant mating types may be identified by the *un* phenotype. The method may be used with both visible and nutritional mutants provided none possesses the *un* type of temperature sensitivity.

H. Branch Howe, jun.

Department of Bacteriology,
University of Georgia,
Athens, Georgia.

[1] Houlahan, M. B., and Mitchell, H. K., *Arch. Biochem.*, **19**, 257 (1948).
[2] Beadle, G. W., and Tatum, E. L., *Amer. J. Bot.*, **32**, 678 (1945).
[3] Newmeyer, D., *Genetics*, **39**, 604 (1954).
[4] Houlahan, M. B., Beadle, G. W., and Calhoun, H. G., *Genetics*, **34**, 493 (1949).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, June 12

INSTITUTE OF CANCER RESEARCH: ROYAL CANCER HOSPITAL (in the Conference Room of the Chester Beatty Research Institute, Fulham Road, London, S.W.3), at 3 p.m.—Prof. Antoine Lacassagne: First Sir Ernest Kennaway Memorial Lecture.

BRITISH SOCIETY FOR THE PHILOSOPHY OF SCIENCE (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. M. Munitz: "The Logic of Cosmology".

Tuesday, June 13

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

Wednesday, June 14

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. Honor B. Fell: "Tissue Culture in Experimental Pathology".*

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Mr. N. T. Gridgeman: "The Sensory Appraisal of Food".

WOMEN'S ENGINEERING SOCIETY (at "Hope House", 45 Great Peter Street, London, S.W.1), at 7 p.m.—Annual General Meeting.

Thursday, June 15

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 4 p.m.—Annual General Meeting. 5.15 p.m.—Mr. A. R. O. Williams: Presidential Address.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. J. A. Shannon: "The National Institutes of Health—Programmes and Problems".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. V. C. A. Ferraro: "Magnetohydrodynamics".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

DEMONSTRATOR IN ORGANIC CHEMISTRY—The Registrar, University College of North Staffordshire, Keele, Staffs (June 14).

ASSISTANT LECTURER IN THE GEOLOGY DEPARTMENT TO TEACH MINERALOGY—The Registrar, King's College (University of London), Strand, London, W.C.2 (June 16).

ASSISTANT LECTURER OR A LECTURER IN APPLIED MATHEMATICS—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (June 17).

ASSISTANT LECTURER (with an honours degree or its equivalent, and a special knowledge of crop and grassland production) IN THE DEPARTMENT OF AGRICULTURE—The Registrar, University College of North Wales, Bangor, North Wales (June 17).

LECTURER (well qualified academically, with teaching, and preferably some industrial experience) IN ORGANIC CHEMISTRY at Hendon Technical College—Clerk to the Governing Body, Town Hall, Hendon, London, N.W.4 (June 17).

LECTURER (with a good honours degree in mathematics and interested in mathematical statistics or in economics with statistics) TO TEACH MATHEMATICS AND MATHEMATICAL STATISTICS to Institute of Statistics and economics degree finals standard—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1 (June 17).

RESEARCH DEMONSTRATOR (graduate in geology), to engage in research; and a RESEARCH ASSISTANT (graduate in geology or chemistry, or graduating this year), to assist the Professor of Geology in a study of the structure and composition of fossil and recent shells—The Registrar, University College of Swansea, Singleton Park, Swansea (June 17).

RESEARCH STUDENTS (with the degree of Bachelor or Master of a British University other than Manchester) IN SCIENCE—The Registrar, The University, Manchester 13 (June 17).

SENIOR LECTURER/LECTURER (qualified in applied mathematics) IN MATHEMATICS—The Registrar, University College of North Staffordshire, Keele, Staffs (June 17).

LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, The University, Aberdeen (June 18).

LECTURER (Grade II) IN THEORETICAL PHYSICS—The Registrar, The University, Bristol 8 (June 19).

SENIOR LECTURER IN MATHEMATICS OR APPLIED MATHEMATICS at the University of Natal, Durban, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, June 20).

GRADUATE IN MECHANICAL ENGINEERING OR APPLIED MATHEMATICS, to conduct research on an aspect of vibration concerned with transport—The Secretary, University College, Gower Street, London, W.C.1 (June 24).

LECTURER IN CROP PRODUCTION—The Secretary, Wye College (University of London), near Ashford, Kent (June 24).

LECTURER IN METALLURGY—The Registrar, The Manchester College of Science and Technology, Manchester 1 (June 24).

ASSISTANT LECTURER (preferably with qualifications in sedimentology and an interest in recent sediments) IN THE DEPARTMENT OF GEOLOGY—The Registrar, University College of Wales, Aberystwyth (June 25).

ASSISTANT LECTURER (preferably applied mathematician) IN THE DEPARTMENT OF MATHEMATICS—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (June 30).

LECTURER IN PHILOSOPHY at Monash University, Clayton, Victoria, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

LECTURER (with a science degree with zoology as a major subject, followed by postgraduate experience leading to a higher degree and/or to published work) IN ZOOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

RESEARCH ASSISTANT (with special interests in climatology and meteorology, and ecology or physical geography) IN GEOGRAPHY—The Secretary, The University, 38 North Bailey, Durham (June 30).

RESEARCH FELLOW (honours graduate in chemistry, biochemistry or agricultural chemistry) IN THE DEPARTMENT OF SOIL SCIENCE, to study chemical changes in forest litter—The Secretary, The University, Aberdeen (June 30).

BIOCHEMIST (with experience in tracer techniques) IN THE DIVISION OF EXPERIMENTAL BIOLOGY AND VIROLOGY—The Secretary, Imperial Cancer Research Fund, Lincoln's Inn Fields, London, W.C.2 (July 1).

CHAIR OF PHILOSOPHY in the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 3).

LECTURER (with a good honours degree) IN PHILOSOPHY at Fourah Bay College, The University College of Sierra Leone—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 5).

CHIEF OFFICER (with a recognized degree or equivalent qualification in botany, agricultural botany or agriculture, and preferably experience in laboratory organization and staff management) OF THE OFFICIAL SEED TESTING STATION—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge (July 7).

LECTURER IN PSYCHOLOGY at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, July 7).

SENIOR LECTURER IN PSYCHOLOGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 15).

SENIOR LECTURER (with experience in concrete technology and structural design) IN CIVIL ENGINEERING at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 25).

CHAIR OF ORGANIC CHEMISTRY, and CHAIR OF CHEMISTRY in the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 31).

READER IN MATHEMATICS at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 31).

SENIOR LECTURER-IN-CHARGE OF THE DEPARTMENT OF PHARMACY, University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 31).

LECTURER (with a degree) IN AGRICULTURAL CHEMISTRY (ANIMAL NUTRITION), and a LECTURER (with a degree or diploma) IN AGRICULTURE (ECONOMICS)—The Principal, Harper Adams Agricultural College, Newport, Shropshire.

POSTDOCTORAL FELLOW IN ORGANOPHOSPHORUS CHEMISTRY—The Secretary, Department of Chemistry, King's College (University of London), Strand, London, W.C.2.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Northampton College of Advanced Technology, London. Report of the Governing Body for 1959–60. Pp. 19. Examination Successes and Prizes, Session 1959–60. Pp. 27. (London: Northampton College of Advanced Technology, 1961.) [203

Ministry of Education: Central Advisory Council for Education (Wales). Technical Education in Wales. Pp. ix + 146. (In English and Welsh). (London: H.M. Stationery Office, 1961.) 7*s.* net. [203

Imperial College of Science and Technology. Postgraduate Courses, 1961–62. Pp. xii + 114. (London: Imperial College of Science and Technology, 1961.) [213

Why a Census: Why do we Need It? How is it Carried Out? What Questions will be Asked? Pp. 31. (London: H.M. Stationery Office, 1961.) 1*s.* net. [223

The Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme. Seventh Annual Report. Pp. 7. (London: Royal Society and Nuffield Foundation, 1961.) [223

Institute of Petroleum. A Glossary of Petroleum Terms. Edited by George Sell. Third edition, revised and enlarged. Pp. vii + 39. (London: Institute of Petroleum, 1961.) 5*s.* [233

Bee Research Association. Handbook, 1961. Pp. 20. (Maidstone: Hon. Publications Secretary, Bee Research Association, 17 Poplar Grove, 1961.) 1*s.* [233

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 47: Sheep Husbandry. Pp. 26. Leaflet No. 86: Manuring Farm Crops. Pp. 15. (Belfast: Ministry of Agriculture, 1961.) [273

Society for the Preservation of Rural Wales, Caernarvonshire Branch. Sixteenth Annual Report, 1959–61. Pp. 26+3 plates. (Plas Hebog, Beddgelert: W. Twiston Davies, Acting Hon. Secretary, 1961.) [273

Anthropology and History. By Prof. E. E. Evans-Pritchard. (A Lecture delivered in the University of Manchester with the support of the Simon Fund for the Social Sciences.) Pp. ii+22. (Manchester: The University Press, 1961.) 3s. 6d. net. [273

Forestry Commission. Forty-first Annual Report of the Forestry Commissioners for the year ended 30th September, 1960. Pp. 66+9 plates. (London: H.M. Stationery Office, 1961.) 5s. net. [273

Johnson, Matthey and Co., Ltd. Booklet No. 1760: Spectrographically Standardised Substances. Pp. 30. (London: Johnson Matthey and Co., Ltd., 1961.) [273

Bulletin of the British Museum (Natural History). Geology. Vol. 5, No. 3: Notes on Eocene Tarsioids and a Revision of some Necrolemurinae. By Elwyn L. Simons. Pp. 43–69+plates 12–14. 12s. Vol. 5, No. 4: Fractured Chert Specimens from the Lower Pleistocene Bethlehem Beds, Israel. By J. Desmond Clark. Pp. 71–90+plates 15–23. 17s. 6d. (London: British Museum (Natural History), 1961.) [273

Department of Scientific and Industrial Research: Geological Survey and Museum. British Regional Geology. The Hampshire Basin and Adjoining Areas. By C. P. Chatwin. Third edition. Pp. iv+99+8 plates. (London: H.M. Stationery Office, 1960.) 5s. net. [273

Report of the Rugby School Natural History Society for the year 1960. Pp. 16. (94th issue.) (Rugby: George Over, Ltd., 1961.) [273

Sir John Cass College. Report, Session 1959–1960. Pp. 25. (London: Sir John Cass College, 1961.) [273

Privy Council. Medical Research Council Report Series, No. 298: Physiological Responses to Hot Environments. Compiled by R. K. Macpherson. (An account of work done in Singapore, 1948–1953, at the Royal Naval Tropical Research Unit, with an appendix on preliminary work done at the National Hospital for Nervous Diseases, London.) Pp. xv+323. (London: H.M. Stationery Office, 1960.) 35s. net. [273

Planning, Vol. 27, No. 451 (27 March, 1961): Four Approaches to the European Problem. By Miriam Camps. Pp. 81–108. (London: Political and Economic Planning, 1961.) 3s. 6d. [283

Other Countries

Institut National pour l'Étude Agronomique du Congo. Carte des sols et de la Végétation du Congo et du Ruanda-Urundi. Le Tableau général Classification des Séries de Sols, ci-joint, est à annexer à la Farde 15—Kasai. (Bruxelles: Institut National pour l'Étude Agronomique du Congo, 1961.) [203

Institut Royal Météorologique de Belgique. Contributions, No. 63: Le Hasard en Météorologie. Par Dr. R. Sneyers. Pp. 21. No. 64: Un Type de Distribution Discrète Tronquée. Par Dr. R. Sneyers. Pp. 9. No. 65: On a Special Distribution of Maximum Values. By Dr. R. Sneyers. Pp. 4. Publication, Série A, No. 15: Rayonnement Solaire à Uccle, Année, 1951. Pp. v+60. Publications, Série B, No. 31: Considérations sur le Climat Solaire à la Base Roi Baudouin d'Après les Résultats Obtenus par l'Expédition Antarctique Belge (1957–1958). Par R. Dogniaux et X. de Maere d'Aertrycke. Pp. 29. (Bruxelles: Institut Royal Météorologique de Belgique, 1960 et 1961.) [203

Nova Scotia Research Foundation, Halifax. Selected Bibliography on Algae, No. 5, containing an author Index to Numbers 1 to 5. Edited by J. Morris and B. L. Anderson. Pp. v+220. (Halifax, N.S.: Nova Scotia Research Foundation, 1960.) 1 dollar. [203

Coconut Research Institute of Ceylon. *The Ceylon Coconut Planters' Review*, Vol. 1, No. 1 (July, 1960). Pp. 1+24. Rs. 1.25. Annual subscription Rs. 5.00. Annual Report of the Coconut Research Institute for 1959. Pp. 74. (Lunuwila: Coconut Research Institute of Ceylon, 1960.) [203

Institut Royal des Sciences Naturelles de Belgique. Mémoires. Deuxième Série, Fasc. 61: Essai Monographique du Genre *Exmalaus* (Coleoptera Phytophaga). Par B. Springlova. Pp. 78. Deuxième Série, Fasc. 62: Chapuis *Platypalidae*: Eine Revision mit Ergänzungen 184. Beitrag zur Morphologie und Systematik der Scolytoidea. Von Karl E. Schedl. Pp. 68. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1960.) [203

Seventy-seventh Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution, 1959–1960. Pp. ii+35+2 plates. (Washington, D.C.: Government Printing Office, 1961.) [203

United States Department of the Interior: Geological Survey. Bulletin 1082-G: Areal Geology of the Little Cone Quadrangle, Colorado. By A. L. Bush, O. T. Marsh and R. B. Taylor. Pp. iv+423–492+plates 18 and 19. Water-Supply Paper 1594-A: Artificial Recharge Through a Well Tapping Basalt Aquifers, Walla Walla Area, Washington. By Charles E. Price. Pp. iv+33. 20 cents. (Washington, D.C.: Government Printing Office, 1960 and 1961.) [213

National Academy of Sciences—National Research Council. NAS–NS 3018: The Radiochemistry of Manganese. By G. W. Leddicotte. Pp. vi+23. (Nuclear Science Series.) (Washington, D.C.: Office of Technical Services, Department of Commerce, 1960.) 50 cents. [213

Connecticut Agricultural Experiment Station, New Haven. Circular No. 208: Diseases and other Disorders of Turf. By Raymond J. Lukens and Ernest M. Stoddard. Pp. 11. Circular No. 209: Soils and Urban Development in Hartford County. By David E. Hill and Arthur E. Shearin. Pp. 8. Circular No. 210: Dedication of Slate Laboratory, June 9, 1959. Pp. 27. Circular No. 211: The Black Vine Weevil. By John C. Schread. Pp. 4. Circular No. 212: Insect Pests of Connecticut Lawns. By John C. Schread. Pp. 10. Circular No. 213: Insects in Houses. By J. P. Johnson and Neely Turner. Pp. 19. Circular No. 214: Cankerworms. By Neely Turner. Pp. 6. (New Haven, Conn.: Connecticut Agricultural Experiment Station, 1959 and 1960.) [213

Connecticut Agricultural Experiment Station, New Haven. Bulletin No. 624: Chemical Control of Weeds and Brush Along Roadsides. By John F. Ahrens. Pp. 32. Bulletin No. 625: Commercial Feeding Stuffs, 1958—Report on Inspection. By H. J. Fisher. Pp. 139. Bulletin No. 626: The Climate of Shade: a Tobacco Tent and a Forest Stand Compared to Open Fields. By Paul E. Waggoner, A. Boyd Pack, and William E. Reifsnyder. Pp. 39. Bulletin No. 627: The Storage of Moisture in Connecticut Soils. By David E. Hill. Pp. 30. Bulletin No. 628: Commercial Fertilizers—Report for 1959. By H. J. Fisher. Pp. 80. Bulletin No. 629: The 62nd Report on Food Products; and the 50th Report on Drug Products, 1957. By H. J. Fisher. Pp. 84. Bulletin No. 630: The Pedigree of Connecticut 49 Shade Tobacco. By Seaward A. Sand. Pp. 12. Bulletin No. 631: Laboratory Studies on House Fly Populations. 3: The Influence of Insecticides on Population Trends. By R. L. Beard. Pp. 22. Bulletin No. 632: Mosquitoes in Connecticut. By Robert C. Wallis. Pp. 30. Bulletin No. 633: Commercial Feeding Stuffs, 1959—Report on Inspection. By H. J. Fisher. Pp. 133. Bulletin No. 634: Plastic Mulching: Principles and Benefits. By Paul E. Waggoner, Patrick M. Miller and Henry C. De Roo. Pp. 44. (New Haven, Conn.: Connecticut Agricultural Experiment Station, 1960.) [213

World Health Organization. Public Health Papers. No. 4: Aspects of Public Health Nursing. By various authors. Pp. 185. 5 Swiss francs; 8s. 6d.; 1.75 dollars. No. 5: Trends in Juvenile Delinquency. By T. C. N. Gibbens. Pp. 56. 2 Swiss francs; 3s. 6d.; 0.60 dollars. World Directory of Venereal-Disease Treatment Centres at Ports: Application of the International Agreement of Brussels, 1924, respecting facilities to be given to Merchant Seamen for the Treatment of Venereal Diseases. Second edition. Pp. 164. 5 Swiss francs; 8s. 6d.; 1.75 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1961.) [213

United States Department of the Interior: Fish and Wildlife Service. Fishery Bulletin No. 174: Development of Eggs and Larvae of Pacific Mackerel and Distribution and Abundance of Larvae, 1952–56. By David Kramer. Pp. iv+393–438, 35 cents. (Washington, D.C.: Government Printing Office, 1960.) 35 cents. [213

A Collection of Papers of the Rational Theory, Book 6. By F. Harrison Stamper. Pp. 12. (Los Angeles, Calif.: F. Harrison Stamper, 1990 Barnett Road, 1961.) [213

Chicago Natural History Museum, Fieldiana: Geology. Vol. 14, No. 4: The Triassic Reptile, *Poposaurus*. By Edwin H. Colbert. Pp. 59–78. 60 cents. Fieldiana: Zoology. Vol. 39, No. 44: On the South American Small-eared Zorro *Atelocynus microtis* Sclater (Canidae). By Philip Hershkovitz. Pp. 505–523. 75 cents. Vol. 39, No. 45: A New Fish from Brazil (Family Trachichthyidae). By Loren P. Woods. Pp. 525–531. 25 cents. Vol. 39, No. 46: A New Pelobatid Frog of the Genus *Megophrys* from Hong Kong. By Robert F. Inger and J. D. Romer. Pp. 533–538. 15 cents. Vol. 39, No. 47: Notes on Two New Guinean Lizards of the Genus *Sphenomorphus*. By Robert F. Inger. Pp. 539–542. 10 cents. (Chicago, Ill.: Chicago Natural History Museum, 1961.) [223

Research Council of Alberta. Forty-first Annual Report, 1960. Pp. v+55. (Report No. 80.) (Edmonton: Research Council of Alberta, 1961.) [233

Merentutkimuslaitoksen Julkaise: Havsforskningsinstitutets Skrift, No. 192: Temperature and Salinity at the Fixed Finnish Stations, July 1954–Dec. 1956. By Folke Koroleff. Pp. 147. No. 193: The Baltic Cruise with *R/V Aranda* 1958—Hydrographical Data. By Folke Koroleff. Pp. 25. No. 194: Vedenkorkeusarvoja 1959. (Sea Level Records for the year 1959.) Av Ilmo Hela. Pp. 59. No. 195: Factors Affecting the Temperature of the Surface Layer of the Sea. By T. Laevastu. Pp. 136. No. 196: Jäätalvu 1959/60 Suomen Merialueilla. (Ice Winter 1959/60 Along the Finnish Coast.) By Erkki Palasuo. Pp. 22. (Helsinki: Merentutkimuslaitos—Havsforskningsinstitutet, 1959 and 1960.) [233

World Health Organization. Specifications for Pesticides: Insecticides, Rodenticides, Molluscicides, Herbicides, Auxiliary Chemicals, Spraying and Dusting Apparatus. Second edition. Pp. 523. 30 Swiss francs; 50s.; 10 dollars. Technical Report Series, No. 205: Expert Committee on Malaria—Eighth Report. Pp. 50. 2 Swiss francs; 3s. 6d.; 0.60 dollars. No. 211: Expert Committee on Addiction-Producing Drugs—Eleventh Report. Pp. 16. 1 Swiss franc; 1s. 9d.; 0.30 dollars. [233

Institut Royal des Sciences Naturelles de Belgique. Mémoires, No. 146: Further Conifers of the Pinaceae from the Wealden Formation of Belgium. By Kenneth Leonard Alvin. Pp. 39+10 plates. Deuxième Série, Fasc. 63: Révision Systématique et Biogéographique des Tabanidae (Diptera) Paléarctiques. Vol. 1: Pangoniinae et Chrysopinae. Par Marcel Leclercq. Pp. 77+10 planches. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1960.) [233

Boletim da Universidade do Paraná. Botanica. No. 1 (Outubro, 1960): Diatomáceas no Trato Digestivo da Regula Viridula Gmelin (Chrystophyta–Bacillariophyceae). Por Hermes Moreira Filho. Pp. 27 (4 plancha). (Curitiba, Paraná: Universidade do Paraná, 1960.) [273

Union of South Africa: Department of Education, Arts and Science. Report of the Archaeological Survey of the Union of South Africa for the year ended 31st March, 1960. Pp. 9. (Annual Report No. 25). (Pretoria: Government Printer, 1960.) [273

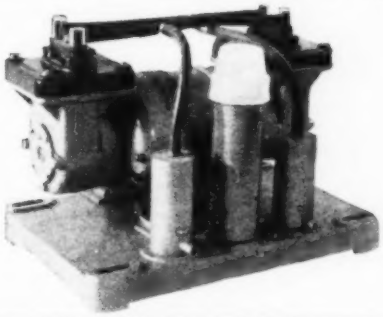
Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.
ST. MARTIN'S STREET, LONDON, W.C.2
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £8 8 -, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2.
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

Small Air Compressors
Vacuum & Liquid Pumps



Please visit us at Stand 42
Laboratory Apparatus and Materials Exhibition
19th–22nd JUNE, 1961

The MU 19.60 Double-ended Air Compressor, illustrated here, may be used in parallel, series or independently.

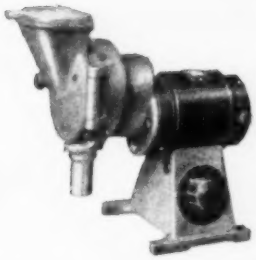
Pressure 0-50 P.S.I.
Vacuum 0-28″ of Mercury
F.A.D. 0-92 C.F.H. Oil Free

CHARLES AUSTEN PUMPS LTD

Petersham Works, High Road, Byfleet, Surrey.
Telephone : BYFLEET 43224

micro
hammer mill

for rapid
analytical
grinding



Pulverises samples of a few grammes with practically complete recovery for analytical work. Only 30 to 120 seconds required for disintegration of majority of substances. Crushes stone, coke, peat, bone, chemicals, wood, grain, wool, cotton, roots, hay, straw . . .

Stainless steel grinding mechanism. Variable-speed motor for better grinding control. Quickly interchangeable slide-in screens for accurate particle size adjustment. Dustproof closure. Mill swings wide open with a mere turn of a thumb-nut allowing rapid, easy and thorough cleaning. Maximum charge 120 c.c.

Also available :
Micro Mixer/Mills for ultra-fine dry and wet grinding for X-ray diffraction, spectroscopy, electron microscopy, powder metallurgy, etc. Micro Pulveriser with cooling jacket. Other small scale laboratory mills.

GLEN CRESTON LTD.

37 The Broadway, Stanmore, Middlesex.
Telephone: Grimsdyke 4218

Plan Ahead

by effecting now "the young man's policy" which gives to a man under 35 immediate life assurance cover at low cost and the valuable right to effect within ten years further assurances even though his health has become impaired.

The Equitable has no shareholders and pays no commission for the introduction of business; unusually attractive terms can, therefore, be offered.

Write today for details to

The Equitable Life Assurance Society

(Founded 1762)

Head Office : **19 Coleman Street, London, E.C.2**

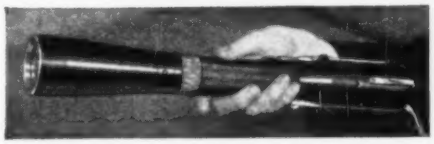
Please send me, without obligation, details of the young man's policy.

Name .....

Address .....

.....

THE ARROW PROJECTION TORCH



The Arrow Projection Torch is designed for use wherever teaching is accompanied by screen illustration. An arrow of high intensity illumination is projected, and may be focused to any distance from 6 to 40 ft.

Now reduced in price

A descriptive and illustrated pamphlet is available and this will be gladly sent on request.

RAYNER

160 NEW BOND STREET, LONDON, W.1
Telephone MAYfair 0128

APPOINTMENTS VACANT

ROYAL COLLEGE OF ADVANCED TECHNOLOGY
SALFORD
PRINCIPAL LECTURESHIPS
SENIOR LECTURESHIPS
LECTURESHIPS
ASSISTANT LECTURESHIPS

The Department of Mechanical Engineering requires engineers and applied scientists to specialize in one or other of the following fields:

Mechanical Vibrations
Control Systems either Hydraulic or Electro-Mechanical
Mechanisms
Engineering Design
Applied Thermodynamics
Fluid Mechanics and in particular Aerodynamics
Strength of Materials
Aeronautical Structures
Production Engineering Technology
Work Study
Engineering Management Studies

These vacancies offer excellent opportunities for technologists to develop their knowledge and experience in one of these fields in a stimulating atmosphere in which personal initiative and individual responsibility are particularly welcomed and valued. This advertisement is directed towards persons with no teaching experience as well as to those with such experience. The present staff of the Department are helping to build up this College of Advanced Technology into a centre of advanced technological studies and research. Staff are expected to develop actively special knowledge in their particular spheres and to carry out research or other technological work as appropriate with postgraduate students or individually. They are also expected to foster the close relations already established with industry which are essential for future development; to this end, staff may engage in consulting work subject to reasonable safeguards. Laboratories, facilities and laboratory staff are excellent and are all currently being substantially increased.

Applicants should normally have an honours degree in engineering or an applied science and, for the lectureships and more senior posts, have had good research or industrial experience. Salaries are in the ranges:

Principal Lecturers—£1,750 rising to £1,900 p.a.
Senior Lecturers —£1,550 rising to £1,750 p.a.
Lecturers —£1,370 rising to £1,550 p.a.
Assistant Lecturers— £700 rising to £1,150 p.a.

In each case, the starting salary will depend on qualifications and experience.

Further particulars and forms of application may be obtained from the Registrar, Royal College of Advanced Technology, Salford 5, Lancs, to whom applications should be returned by June 23, 1961.

WEST OF SCOTLAND BLOOD TRANSFUSION SERVICE
RESEARCH ASSISTANT

Applications are invited from Science Graduates with an interest in either biology or chemistry. Previous research experience is desirable but not essential and applications from recent graduates will be considered. The duties are concerned with the investigation of immunological problems. The appointment will be within the salary scale £650 to £1,150 per annum with placing according to qualifications and experience. Other conditions are as laid down by the appropriate Whitley Council and the post is superannuable under the National Health Service (Scotland) regulations. The work will be carried out in the laboratories of the Regional Transfusion Service at Law Hospital, Carluke, Lanarkshire, which is situated approximately 20 miles from Glasgow and 30 miles from Edinburgh. Working facilities are excellent including a modern freeze drying unit and low temperature rooms. Living accommodation for an unmarried person will be available.

Applications should be addressed to the Regional Director, Blood Transfusion Service, Law Hospital, Carluke, Lanarkshire.

INSTITUTE OF CHILD HEALTH
UNIVERSITY OF LONDON

Laboratory Technician required for the Neonatal Unit at the Hammersmith Hospital, Ducane Road, W.12. Biochemical experience an advantage. A.I.M.L.T. or equivalent preferred. Salary, Senior Technician II, Whitley Scales.

Apply to the Secretary, Institute of Child Health, the Hospital for Sick Children, Great Ormond Street, W.C.1, giving age, experience and qualifications.

AUSTRALIA
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

RESEARCH STAFF

(No. 464/233) (Several Positions)

The Organization's **Division of Textile Industry, Geelong, Victoria,** invites applications for research positions from honours graduates in science, or engineering with some years post-graduate research experience.

The Division, one of three constituting the Wool Research Laboratories, is broadly concerned with development of new physical and chemical techniques in wool textile processing and provides well-equipped laboratories for fundamental studies and full scale mill equipment for application of results. The wide field of research includes absorption studies on wool, fibre friction, permanent setting, shrinkage prevention, mechanical action of machines on wool fibres, servo-control mechanisms in processing and development of new machines.

The appointees will carry out duties in the following fields:

(i) Chemical studies on modification of wool fibres. This work would involve the study of reactions with a view to developing new fabric finishes;
(ii) The development of new physical methods for separating vegetable material from wool;
(iii) Physical studies on fibre friction, and the effects of lubricants;
(iv) Investigation of new methods of yarn production;
(v) Fibre behaviour in processing using radioactive and high speed photographic techniques.

Applications and enquiries from research workers in fields not strictly related to the above are also warmly invited.

SALARY: Dependent on qualifications and experience within the ranges, £A.1,510 to £A.2,265 per annum or £A.2,395 to £A.2,720 per annum.

EXPERIMENTAL OFFICER

(No. 464/232)

The Organization's **Division of Textile Industry, Geelong, Victoria,** also invites applications for a position as Experimental Officer from graduates in Electrical Engineering, or in Science with Physics and Electronics as major subjects (or equivalent professional qualifications). Experience in design of electronic equipment is essential.

The appointee will be required to assume full responsibility for an electronics laboratory. The function of the laboratory will be to develop special electronic devices for application in research on woollen and worsted processing; to advise research staff in projects of an electrical engineering nature; and to provide servicing facilities for all electronic equipment of the Division. First-class laboratory facilities available.

SALARY: Dependent on qualifications and experience within the ranges, £A.1,620 to £A.1,950 per annum or £A.2,070 to £A.2,330 per annum.

Salary for a woman will be £A.180 per annum less than corresponding rates for men.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the range within which the original appointment is made.

Fares paid. Further particulars supplied on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting relevant Appointment number) should be addressed by August 5, 1961.

UNIVERSITY OF MANCHESTER

Applications are invited from graduates in Chemistry or Biochemistry for the post of Research Assistant in Chemistry under the auspices of the British Empire Cancer Campaign Committee to work in the Department of Chemistry of the Faculty of Science under the direction of Dr. G. R. Barker, on the chemistry and biochemistry of nucleic acids. It is expected that the person appointed would use the work towards obtaining a higher degree. Applications from persons intending to graduate this summer would also be considered. Salary would be £350 per annum. The person appointed would be required to take up duties on October 1, 1961.

Applications should be sent not later than June 17, 1961, to the Registrar, The University, Manchester, 13, from whom further particulars and forms of application may be obtained.

UNIVERSITY OF SHEFFIELD

Applications are invited for a post of Lecturer or Assistant Lecturer in Physics to begin duties on October 1, 1961. Initial salary according to qualifications and experience on the scales: Lecturer, £1,050 by £50 to £1,400 by £75 to £1,850; Assistant Lecturer, £800 by £50 to £950 with F.S.S.U. provision and family allowance. A grant towards removal expenses will be made.

Further particulars may be obtained from the Registrar, to whom applications (four copies) should be sent by July 1, 1961.

NATIONAL INSTITUTE OF AGRICULTURAL BOTANY

Applications are invited for the post of Chief Officer of the Official Seed Testing Station. Applicants must hold a recognized degree or equivalent qualification in botany, agricultural botany, or agriculture. Experience in laboratory organization and staff management is also desirable. Commencing salary £1,840 by annual increments to £2,540. Superannuation under F.S.S.U.

Further particulars and form of application are obtainable from M. G. Tozer, Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge. Closing date July 7.

JOHN INNES INSTITUTE REQUIRE A Scientific Officer or Senior Scientific Officer to work on biochemical aspects of genetics. The successful applicant will be expected, in the first instance, to assist in current research on the effects of mutation on the structure of specific protein in the mould *Neurospora crassa* but there will also be scope for the development of individual lines of research. Applicants should have research experience in enzymology and/or protein chemistry, and some knowledge of and interest in fundamental genetic problems. Salary in the scale £750 to £1,342 per annum, according to age and qualifications. F.S.S.U.

Applications, with the names of two referees, should reach the Secretary, Bayfordbury, Hertford, Herts, by June 30, 1961.

AUSTRALIAN NATIONAL UNIVERSITY

INSTITUTE OF ADVANCED STUDIES
JOHN CURTIN SCHOOL OF MEDICAL RESEARCH
RESEARCH FELLOWSHIP IN PHYSICAL BIOCHEMISTRY

Applications are invited for a Research Fellowship in the Department of Physical Biochemistry.

Research experience in biochemistry or chemistry and interest in physico-chemical aspects of biochemistry are essential. The Research Fellow will be allowed reasonable scope in the choice of his research.

The salary range for Research Fellows is £A.1,625 to £A.2,450, with increments of £A.75 per annum; initial salary will depend on qualifications and experience. Appointment is for three years, with possible extension to a maximum of five years.

Superannuation is on the F.S.S.U. pattern. Reasonable travel expenses are paid and assistance with housing is provided.

A summary of the conditions of appointment is available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close in Australia and London on June 30, 1961.

Details of the research being carried out may be obtained from the Head of the Department, Professor A. G. Ogston, F.R.S.

NEW ZEALAND

EDUCATION DEPARTMENT

Applications are invited for the undermentioned vacancy: Inspector of Post-Primary Schools (Technical), Head Office, Department of Education, Wellington, New Zealand. Duties: To assist the Superintendent of Technical Education in the development of Senior Technical education. Location: The appointee will be attached to Head Office, Wellington, but may be required to travel anywhere in New Zealand. Salary: The salary range for the position is from £1,600 to £1,900 per annum. Commencing salary will depend on experience and qualifications of the applicant, and is payable from the day of taking up duty in New Zealand. Qualifications: Applicants should be well qualified in chemistry or one of the biological sciences, and should, if possible, have had industrial as well as teaching experience. Conditions: The successful applicant will be expected to take up duties in New Zealand as soon as possible. Passages: Steamer fares of up to £172 each for the appointee and his wife, and pro rata for dependent children, will be paid. Incidental Expenses: Up to £35 for a single person and £100 for a married man can be claimed to cover the cost of taking personal effects to New Zealand.

Application forms and further details are available from the High Commissioner for New Zealand, 415 Strand, London, W.C.2, with whom applications will close on June 26, 1961. Please quote reference B13/6/1 when inquiring.

MINISTRY OF AGRICULTURE, FISHERIES and Food. Pensionable post at Letcombe Regis for man or woman as (a) Senior Scientific Officer or (b) Scientific Officer, for research into environmental monitoring around nuclear establishments (e.g., design, operation, and interpretation). Considerable travelling involved. Age limits (on December 31, 1961): (a) at least 26 and under 32, (b) at least 21 and under 29. Extension for candidates with regular Forces service and Overseas Civil Service. Qualifications: normally a degree, or Dip.Tech., with first- or second-class honours in physics, mathematics, or chemistry, or equivalent attainment. Understanding of grassland husbandry, animal management, and the statistics of sampling, together with a general agricultural background, essential. Car driving necessary. Additionally, for (a), at least three years' postgraduate experience required. Final year students may apply for (b). Salary on (interim) scales £1,302 to £1,604 or £717 to £1,186. Starting salary may be above minimum in either case.—Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting **S/52-53/61/ARC.**

EXPERIENCED CHEMIST METALLURGIST who wants to help prepare highly technical literature in the west of London area, even though not greatly experienced in this field, is invited to apply below. The position is permanent. Salary will be according to qualifications and experience.—Box No. 970, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

POST-DOCTORAL FELLOWSHIPS IN PROTEIN CHEMISTRY

The Organization's Division of Protein Chemistry, Melbourne, Victoria, invites applications from graduates in Chemistry or Physics for Post-Doctoral Fellowships. Applicants should have had research experience either in the protein field or with physical or chemical techniques which would find application in this field.

The Fellows selected will join a group of 25 research workers investigating various aspects of protein structure and chemistry. The protein research programme which has been developed by this group over the past twelve years provides an excellent opportunity for gaining experience in this field. A wide range of research equipment for chemical, physico chemical, biophysical and histological studies on proteins is available and a choice of projects relating to both fibrous and globular protein will be offered for selection.

The Fellowships are offered for a period of three years.

SALARY: Commensurate with qualifications and experience; minimum offered £A.1,750 per annum up to a maximum of £A.2,720 per annum. Salary for women will be £A.180 per annum less than corresponding rate for men.

Return fares paid. Further particulars of conditions, etc., supplied on application to: **Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2.**

to whom applications (quoting Appointment No. 462/127), should be addressed by August 19, 1961.

ICI

PLANT PROTECTION LIMITED

(a subsidiary company of IMPERIAL CHEMICAL INDUSTRIES LIMITED)

requires a ZOOLOGIST in the ENTOMOLOGY section of its RESEARCH AND DEVELOPMENT DEPARTMENT at JEALOTT'S HILL, near BRACKNELL, BERKSHIRE.

Applicants should possess a good honours degree in ZOOLOGY and postgraduate experience in branches of that science. They should not exceed 35 years of age, and should write in the first instance, giving brief particulars only, to THE STAFF OFFICER, PLANT PROTECTION LIMITED, FERNHURST, HASLEMERE, SURREY.

MATHEMATICIAN

Reed

A vacancy occurs for an Applied Mathematician aged 25 to 35 in the Group Research Department of the Reed Paper Group. The Department deals with a variety of problems concerning Packaging and Paper and Board manufacture, which necessitate research in the fields of Elasticity and Hydrodynamics.

Applicants should have a higher degree (preferably M.Sc.) and research experience in these subjects, and some industrial experience would be an advantage, although this is not essential.

Applications, in writing, with details of age, experience, and present salary, should be addressed to:

The Group Personnel Officer, Albert E. Reed & Co. Ltd., Larkfield, nr. Maidstone, Kent,
quoting reference M.GR.10

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

INORGANIC OR PHYSICAL CHEMIST

The Organization's **Division of Mineral Chemistry, Chemical Research Laboratories, Melbourne, Victoria,** invites applications for a position as Inorganic or Physical Chemist from Honours graduates in Science with some years post-graduate research experience or equivalent qualifications. A good basic training in structural inorganic chemistry is desirable but not essential.

One of the Division's investigations concerns the development of new electrochemical sources of power and the conservation of power in electrolytic processes of industrial importance. This subject touches on many branches of chemistry, i.e., electrode kinetics, catalysis, semiconduction, oxidation mechanisms of fuels of an organic or inorganic nature and the appointee, whose precise duties will depend on his experience, will join a group of research staff with considerable experience in pure and applied electrochemistry.

SALARY: Dependent on qualifications and experience within the ranges, £A.1,510 to £A.2,265 per annum or £A.2,395 to £A.2,720 per annum.

The appointment will be for a fixed term of three years, but with strong possibility of extension to more permanent basis at the end of the term.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the range within which the original appointment is made.

Return fares paid. Further particulars supplied on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting Appointment No. 601/5) should be addressed by July 15, 1961.

ICI

PLASTICS DIVISION

The rapid expansion of this Division, already the largest manufacturers of plastics materials in the Commonwealth, gives rise to vacancies for:

PHYSICAL AND ORGANIC CHEMISTS

IN OUR RESEARCH DEPARTMENT

We require men with good Honours degrees and Research experience, who are capable of creative thinking, for

(a) exploratory organic work aimed at the discovery of new polymers;

(b) Physico-chemical studies of polymerization reactions and the characterization of the products;

(c) development of new products and processes from the laboratory scale up to the production plant.

Pension and Profit-sharing Schemes are in operation and for married men temporary lodging allowances are available, and assistance is given towards house purchase and removal expenses.

Apply briefly to:

The Staff Manager,
Imperial Chemical Industries Limited,
Plastics Division,
Bessemer Road, Welwyn Garden City, Herts,
quoting reference No. 5122/Y.

UNIVERSITY OF LONDON KING'S COLLEGE

Applications are invited for a Postdoctoral Fellowship in ORGANOPHOSPHORUS CHEMISTRY, tenable for one year from October 1, 1961, in the first instance, with possible extension.

The successful applicant will be expected to carry out research in collaboration with Dr. J. I. G. Cadogan.

Salary Scale: £900 by £50 to £1,000 per annum with F.S.S.U. benefits.

Applications in writing, giving details of age and experience, to Secretary, Department of Chemistry, King's College, Strand, W.C.2.

SERIAL 498

AGRICULTURAL RESEARCH STAFF

To meet the requirements of a rapidly expanding research programme the **CAMEROONS DEVELOPMENT CORPORATION** invites applications for the posts of

SENIOR PLANT BREEDER

and

SENIOR AGRICULTURAL CHEMIST

directly responsible to the Head of the Research Division. The Corporation is currently engaged on a planting programme of over 6,000 acres, and at present has 55,000 acres under cultivation with rubber, oil palms, bananas, cocoa, and tea offering scope for a wide field of research.

The terms of service include free housing with heavy furniture supplied, free electricity, and free medical treatment. A children's allowance of £75 per annum for each child to a maximum of two children, plus two free air passages per child during the tour if they are at school outside the Territory. Tours are normally for 15 or 18 months depending on age and seniority.

The appointments will be in the Principal Scientist grade at a salary inclusive of inducement allowance in the range of £2,000 to £2,450 per annum. In addition the Corporation has a bonus scheme for its staff and contributes to the Provident Fund at the rate of 15 per cent of the employee's salary.

Applicants should send full particulars, quoting **Serial 498**, to the

Personnel Officer,
Colonial Development Corporation,
33 Hill Street, London, W.1.

UNIVERSITY OF BRISTOL

Applications are invited for the post of Lecturer (Grade II) in Theoretical Physics tenable from October 1, 1961. Salary scale £1,050 by £50 to £1,400 by £75 to £1,475 (bar); £1,475 by £75 to £1,850. Preference will be given to candidates having special interests in elementary particle theory or solid state theory.

Full particulars may be obtained from the Registrar, University, Bristol 8, to whom applications should be sent by June 19.

BIRKBECK COLLEGE
(UNIVERSITY OF LONDON)

Applications are invited for the post of Assistant Lecturer or Lecturer in Mathematics. Candidates are required to have special qualifications in Geometry. Scales of salary: Assistant Lecturer, £800 by £50 to £950 per annum; Lecturer, £1,050 by £50 to £1,400 by £75 to £1,550; (bar) £1,625 by £75 to £1,850 per annum. London allowance of £60 per annum is payable in addition in both grades.

Further particulars should be obtained from the Secretary, Birkbeck College, Malet Street, W.C.1. Closing date: June 26, 1961.

AUSTRALIAN NATIONAL UNIVERSITY

JOHN CURTIN SCHOOL OF MEDICAL RESEARCH

DEPARTMENT OF BIOCHEMISTRY

Applications are invited for a Fellowship and a Research Fellowship in the Department of Biochemistry. Applicants for the Fellowship will be expected to have specialized in organic chemistry, with special reference to the chemistry of those compounds of biochemical significance. The salary range for a Fellow is £A.2,120 to £A.3,000. Appointment is for an initial period of five years; thereafter it may be made permanent. A Fellow is entitled to one year's study leave on full pay, plus a contribution towards travel and other expenses, in every seven years. Applicants for the Research Fellowship must have research experience in biochemistry, with emphasis on enzymology or intermediary metabolism; the successful applicant will be allowed reasonable scope in the choice of his research topic. The salary range for a Research Fellow is £A.1,625 to £A.2,450, and appointment is for three years, with possible extension to a maximum of five years. In both cases commencing salary will depend on qualifications and experience. Superannuation is on the F.S.S.U. pattern. Reasonable travel expenses are paid and assistance with housing is provided.

Further details should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on July 3, 1961.

BRITISH INDUSTRIAL BIOLOGICAL RESEARCH ASSOCIATION, LIMITED

APPOINTMENT OF INFORMATION OFFICER

Applications are invited from men or women for the post of Information Officer to this new research association, recently formed with the support of the Department of Scientific and Industrial Research to carry out toxicological investigations on substances used in the production, processing and packaging of food and cosmetics. The Association hopes to establish its research station at Leatherhead, Surrey, but until then its offices will be in London. The Information Officer will be required to build up an efficient information service based upon the research results of this and other organizations working in the same field and covering legislation on food additives and contaminants throughout the world. He will also be responsible for the Association's technical library. Candidates should be scientifically qualified and have had experience in a similar capacity. The starting salary will be about £2,000 per annum, depending on age, qualifications and experience, and pension provision will be made.

Applications should be sent by July 10 to the Acting Secretary, 11 Green Street, London, W.1, from whom further particulars of this post can be obtained.

ROWETT RESEARCH INSTITUTE

Assistant Experimental Officer wanted, with experience in analytical chemistry, to work on protein and carbohydrate metabolism in ruminants. Candidates should, if aged 22 years or over, possess a University pass degree in Science, A.R.I.C. or Higher National Certificate in Chemistry or equivalent qualification. Salary scale £578 (age 21) to £957. Candidates aged 26 or over enter at £776. A Superannuation Scheme is in force.

Applications, stating date of birth with particulars of qualifications and experience, together with the names of three referees, should be sent to the Secretary, Rowett Research Institute, Bucksburn, Aberdeen.

UNIVERSITY OF NOTTINGHAM

RESEARCH ASSISTANT IN AGRICULTURAL BOTANY

Applications are invited for the above appointment in the Department of Agricultural Sciences at the School of Agriculture, Sutton Bonington, to carry out ecological and genetic studies on natural hybrids between ryegrass and meadow fescue. The appointment is for three years from September 1, 1961, salary £400 per annum. Applications will be considered from honours graduates (including prospective graduates this summer) in botany or agricultural botany. The successful candidate will be expected to read for a higher degree.

Conditions of appointment and form of application, to be returned by June 30, from the Registrar, the University, Nottingham.

ENGLISH ELECTRIC VALVE CO. LTD.

Chelmsford, Essex

The Company has in production high quality germanium and silicon power rectifiers in ratings up to 20 amps.

Improvement in the processes involved in the manufacture of these devices continues in order to increase their reliability in service.

The Company wishes to engage a senior production-development engineer to accept responsibility in the development and production of the rectifiers in current demand, and other devices that the Company wish to market after development.

A substantial salary will be paid to an engineer or physicist possessing sound experience in the semi-conductor field and post-graduate qualifications. Preferred age range 28 to 40.

Applications outlining experience and qualifications should be sent to: Group Personnel Services, English Electric House, Strand, London, W.C.2. Please quote reference N.1594.K.

BEECHAM GROUP

RESEARCH SCIENTIST

An opportunity with excellent prospects is being created by expansion activity in nutritional research.

A seasoned graduate (first- or second-class honours) is sought with experience in one or more of the following fields:

Biochemistry.
Food Chemistry.
Nutrition.

A postgraduate qualification is desirable, but appropriate experience would be an equivalent asset.

The successful applicant would work in the Basic Research Unit at Brentford, and be directly responsible to the Manager of the Unit. Prospects are excellent for the right man.

Applications, giving full details of age, qualifications and experience, and quoting reference RS 132, should be addressed to the Personnel Director, Beecham Group Limited, Beecham House, Great West Road, Brentford, Middlesex.

WELSH COLLEGE OF ADVANCED TECHNOLOGY

DEPARTMENT OF CHEMISTRY AND BIOLOGY

Applications are invited for the post of Assistant Lecturer, Grade B, to assist with teaching in Higher National Certificate and Graduate R.I.C. courses with special reference to Inorganic and Analytical Chemistry. Applicants should have a good honours degree in Chemistry or an equivalent high qualification. A higher degree is desirable. An active interest in research is essential. Salary scale: £700 by £27 10s. to £1,150 with appropriate allowances for training and experience.

Further particulars and forms of application may be obtained on application to the Registrar, at the College, Cathays Park, Cardiff, to whom completed forms should be returned by June 24, 1961.

ROBERT E. PRESSWOOD,
Clerk to the Governors.

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY GLASGOW

ASSISTANT LECTURER

Applications are invited from candidates with suitable qualifications (interest in Fuel Technology an advantage) for appointment in the Department of Chemical Technology. Research, for which excellent facilities are available, is encouraged. Salary scale £800 to £950 with F.S.S.U. and family allowances.

Forms of application from the Secretary, George Street, Glasgow.

COLLEGE OF AERONAUTICS

A Lecturer in Metallurgy is required in the Department of Materials to lecture at post-graduate level on the fundamental metallurgical aspects of technological processes. Research experience in an industrial environment would be valuable, and the possession of a higher degree is desirable. The person appointed will be responsible for the development of a new laboratory; for teaching in his own special subjects; for the supervision of student research work, and also for initiating and directing long-term programmes of research, some of which may be under external sponsorship. Salary in scale £1,050 by £50 to £1,400 by £75 to £1,850 per annum with superannuation under F.S.S.U. and family allowance, commencing salary depending upon age, qualifications and experience. Consideration given to housing requirements.

Applications, giving full particulars and the names and addresses of three referees, should be forwarded to the Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks. Further particulars available.

UNIVERSITY OF BRISTOL

Applications are invited for the following posts in the Department of Physics. (a) Lecturer (Grade II) in Physics. Salary scale £1,050 to £1,475 (bar); £1,550 to £1,850. Preference will be given to applicants with an interest in either Low Temperature Physics or some aspect of Solid State Physics. (b) Research Associate in Low Temperature Physics. Salary scale £1,050 to £1,475. Applicants in the general field of Solid State Physics will also be considered.

Full particulars of these appointments may be obtained from the Registrar, University, Bristol 8, to whom applications should be sent by June 19.

PILKINGTONS

The greatest name in the world of GLASS

PHYSICISTS are required for fundamental and applied research in solid state, reaction kinetics, thermo dynamics, spectroscopy, X-ray techniques and electronics, in the recently completed laboratories in the country ten miles from St. Helens.

MECHANICAL ENGINEERS are required for process and product development on existing plant, design and operation of pilot plant, in the Technical Development Centre at St. Helens, and also at Birmingham, Doncaster, Glasgow and St. Asaph.

MATHEMATICIANS are required for fundamental research, computer investigation, work study, quality control and statistics.

Graduates are invited to apply to the

Personnel Officer (Graduate Recruitment)

PILKINGTON BROTHERS LIMITED

St. Helens **Lancashire**

CANADA | ***Research Opportunity in Metal Physics***

Physical Metallurgy Division
Department of Mines and Technical Surveys, Ottawa

Attractive career opportunity for Physical Metallurgists or Physicists with postgraduate training and research experience to work with a group carrying out fundamental investigations in Metal Physics.

For details and application forms write to:
Dept. 1504,
National Employment Service of Canada,
61 Green Street, London, W.1.

ESTABLISHED
PHARMACEUTICAL COMPANY

in South Cheshire requires an Honours Graduate in Chemistry or Biochemistry, or A.R.I.C.; to develop a unit for the investigation of the chemical aspects of a wide range of problems connected with the development and control of pharmaceutical and biological materials.

The proposed unit will work in close co-operation with pharmaceutical and biological laboratories under the general direction of a Research Manager. The position is permanent, pensionable, and offers opportunity for rapid progress for the right man. Initially, salary will be appropriate to experience. Applicants should preferably be below 30 years of age and concerned to widen their technical experience.

Applications—which should be in full—will be treated in the strictest confidence.

Box No. 969,
T. G. Scott and Son, Ltd.,
1 Clement's Inn, London, W.C.2.

KENT EDUCATION COMMITTEE
NORTH-WEST KENT COLLEGE OF TECHNOLOGY
SCIENCE DEPARTMENT

Assistant Grade B (male) to teach Chemistry, Physics and some Mathematics to Ordinary Level G.C.E. standard. Duties to commence September 1, 1961. Library and Research Laboratory available. Salary: £700 by £27 10s. to £1,150 plus degree allowance.

Application forms and further details obtainable from the Principal at the College, Miskin Road, Dartford, Kent.

QUEEN MARY COLLEGE
(UNIVERSITY OF LONDON)

Applications are invited for the post of Assistant Lecturer in the Department of Mathematics, tenable from October 1, 1961 (an Applied Mathematician preferred). Salary scale £800 by £50 to £950 plus a London allowance of £60. F.S.S.U. participation and family allowance of £50 for each child.

Application forms, obtainable from the Registrar, Queen Mary College, Mile End Road, E.1, to be returned by June 30.

HERIOT-WATT COLLEGE
EDINBURGH
LECTURESHIP IN MICROBIOLOGY

Applications are invited from men or women holding an Honours Degree for Lectureship in Microbiology in the Department of Brewing and Applied Biochemistry. Applicants, who should be able to take up duty in September, 1961, or soon thereafter, should be prepared to take special interest in the industrial implications of the subject and be further qualified in Organic Chemistry and/or Biochemistry. Industrial and/or research experience would be an advantage though not essential. The successful candidate will be expected to contribute to the research programme of the Department. Salary scale £1,050 by £50 to £1,700, on which the successful candidate may be placed according to qualifications and experience.

Further particulars and forms of application, which must be returned by June 30, may be obtained from the Principal.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING
(UNIVERSITY OF READING)

Applications are invited from suitably qualified honours graduates for a post in the Bacteriology department. The work will be concerned with the microbiology of the rumen and experience in this field will be an advantage, but is not essential. Appointment in Scientific Officer grade (£717 to £1,222) or Senior Scientific Officer grade (£1,302 to £1,654) according to qualifications and experience; F.S.S.U.

Apply, naming two referees, to Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 61/17.

COLLEGE OF AERONAUTICS

ADVANCED STUDENTSHIPS IN MATERIALS SCIENCE AND ENGINEERING

A number of advanced studentships are available in the Department of Materials to enable Honours Graduates in Science or Engineering to enter one-year or two-year postgraduate courses in Materials Science and Engineering. These studentships are provided by certain well-known industrial organizations, and each selected candidate will be appointed to the staff of one of these organizations, by arrangement, on admission to the course, at the salary of £850 per annum. His tuition fee will also be paid. The course work comprises lectures and laboratory work, selected to meet the needs of the individual from a wide range of subjects dealing comprehensively with both metallic and non-metallic materials, and will include a research project under personal supervision. Successful completion of the course will lead to the award of the Diploma of the College of Aeronautics (D.C.Ae.) or the Diploma in Advanced Engineering (D.A.E.) according to the nature of the course undertaken. Those suitably qualified might be able to submit work for a higher degree.

Further information on the courses available and application forms may be obtained from the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

SERIAL 497

AGRICULTURAL RESEARCH STAFF

To meet the requirements of a rapidly expanding research programme the CAMEROONS DEVELOPMENT CORPORATION invites applications for the posts of

PLANT BREEDER
ENTOMOLOGIST
PLANT PATHOLOGIST
AGRONOMIST

in its Research Division. These posts offer scope for a wide field of research in a commercial organization with some 55,000 acres under cultivation with rubber, oil palms, bananas, cocoa, and tea, and a current development programme of 6,000 acres.

The terms of service include free housing with heavy furniture supplied, free electricity, and free medical treatment. A children's allowance of £75 per annum for each child to a maximum of two children, plus two free air passages per child during the tour if they are at school outside the Territory. Tours are normally 15 to 18 months, depending on age and seniority.

The appointments, according to qualifications and experience, will be made in the following grades:

Senior Scientist with a salary range inclusive of inducement allowance between £1,550 to £2,000 per annum.

Scientist with an inclusive salary range £1,225 to £1,575 per annum. In addition the Corporation has a bonus scheme for its staff and contributes to the Provident Fund at the rate of 15 per cent of the employee's salary.

Applicants should send full particulars, quoting **Serial 497**, to the Personnel Officer, Colonial Development Corporation, 33 Hill Street, London, W.1.

MINISTRY OF AGRICULTURE, FISHERIES and Food: Field Officers. Up to 75 pensionable posts for men and women at least 18 on May 1, 1961. Qualifications: Normally G.C.E. (or equivalent) with not less than four passes, or successful completion of a course at an agricultural institute; background knowledge of agriculture including wide experience of farm life. Candidates without formal qualifications, but with suitable experience, may be considered. Car driving essential. Duties include visiting farms in connection with grants, subsidies, crop returns, training schemes, etc.; calf certification, control of foul brood disease (bees), sugar beet eelworm or restoration of opencast sites. National starting salary from £458 at 18 to £764 at 25 or over. Scale maximum £983. Promotion prospects.—Write Civil Service Commission, Burlington Gardens, London, W.1, for application form, quoting **5306/61**. Closing date July 4, 1961.

Standard Telephones and Cables Limited

have a vacancy in their Rectifier Division, Harlow, Essex, for a

Chief Engineer

He will be responsible to the Division Manager for the engineering activities of a factory employing 1,400 people in the manufacture of electrical components such as semi-conductor power rectifiers, selenium rectifiers, power transformers, and resistors.

He will control the Development and Engineering Departments, which comprise 180 scientific and technical employees, of whom about one-third are graduates or professional engineers.

Applicants, aged not less than 30, must have a professional or academic qualification in physics or electrical engineering. They should have experience in a senior post in the electronics industry and should preferably be in charge of an engineering department.

Initial salary will probably be between £2,000 and £2,500 a year, although a higher figure would be considered for an exceptional candidate. Working conditions are excellent and a non-contributory pension scheme is in operation. Housing could be made available.

Please send applications, which will be treated in strict confidence, to

Manpower Section, Personnel Department,
STANDARD TELEPHONES AND CABLES LIMITED,
Connaught House, 63 Aldwych, London, W.C.2.
quoting ref. N/06.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

ENGINEERING DEPARTMENT

A TESTING OFFICER is required for performance testing of dairy machinery. Applicants should preferably have experience of engineering testing work and an educational qualification to H.N.C. standard.

The appointment will be made in the Experimental Officer grade, the salary scale for which is £1,057 to £1,336 per annum with superannuation.

Applications stating qualifications and experience, age and present appointment, to the Secretary, N.I.R.D., Shinfield, Reading, quoting Ref. 61/3.

UNITED KINGDOM TECHNICAL ASSISTANCE

The Commonwealth Relations Office invites applications for the following posts in Pakistan, each lasting two years:

Professor of Analytical Chemistry. The Post-graduate Department of Chemistry has been functioning since 1955. Analytical Chemistry has now been introduced in M.Sc. Final and a Professor is needed to cope with its teaching including the instrumental methods of analysis.

Professor of Nuclear Physics. To teach graduates reading for postgraduate degrees and assist in setting up a laboratory.

Professor of Hydraulics Engineering. To teach up to degree level and develop the laboratories.

Readers, Senior Lecturers and Lecturers with appropriate qualifications would be considered.

Salary for all posts: £2,600 to £3,600 per annum, according to qualifications and experience plus tax free allowance, £1,900 per annum (married), £1,125 (single) and additional allowances for children. Free furnished accommodation or refund of 45 per cent of basic hotel bills. U.K. superannuation position will be preserved during tour of duty. All emoluments paid by the U.K. Government.

For further information and application form write to Ministry of Labour (E.9), 26-28 King Street, London, S.W.1, quoting PAK/527.

AUSTRALIA

THE UNIVERSITY OF NEW SOUTH WALES LECTURER—SCHOOL OF PSYCHOLOGY

The University of New South Wales wishes to appoint a Lecturer to the School of Psychology at Sydney. The School is responsible for honours courses in psychology offered to students in the Faculties of Arts and Science. Graduate and postgraduate research programmes are in operation. Applicants should have a degree with honours in psychology and be interested in pursuing research. The University will consider applicants with experience in any field of psychology, but will give special preference to those whose qualifications and research experience are in learning theory and general psychology. Salary: £A.1,772 range £A.2,477 per annum. Commencing salary is determined by qualifications and experience. Successful applicant will be eligible, subject to passing a medical examination, to contribute to the State Superannuation Fund. First-class ship fares to Sydney of appointee and family will be paid.

Four copies of applications (including the names of two referees), should be lodged with the Agent-General for New South Wales, 56-57 Strand, London, W.C.2, and a copy forwarded to the Appointments Section, Box 1, Post Office, Kensington, New South Wales, by airmail to arrive before July 28, 1961. Applicants outside the United Kingdom and Eire need only submit one copy of their application to the London address in addition to that sent to Sydney.

UNIVERSITY MUSEUM

DEPARTMENT OF GEOLOGY AND MINERALOGY OXFORD

Applications are invited from chemists, physicists or geologists for a post of Research Assistant in the Geological Age and Isotope Research Group, to assist in the determination of ages of rocks by methods based on natural radioactivity and involving chemical and physical means of analysis, including mass spectrometry. The post is suitable for a person holding a pass or general degree (or equivalent). The appointment, under the terms of a D.S.I.R. grant, would be for one year in the first instance, with the likelihood of renewal for a further period, and carries a salary in the range £700 to £850 per annum.

Candidates, including those expecting to graduate this year, should apply, giving particulars, to Professor L. R. Wager, F.R.S., at the above address.

NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

SCIENTIFIC OFFICERS

The National Institute for Research in Nuclear Science was formed in 1958 to provide for the common use of Universities those large and expensive facilities which are nowadays required for nuclear research. In the Rutherford High Energy Laboratory situated near Harwell in Berkshire two accelerators are planned; a 50 MeV. proton linear accelerator, which is already in operation, and a 7 GeV. proton synchrotron due for completion at the end of 1962.

Applications are invited from Graduate

PHYSICISTS
THEORETICAL PHYSICISTS
ENGINEERS

for research posts at the Rutherford High Energy Laboratory, Harwell.

There are vacancies in the following groups:

7 GeV. Proton Synchrotron (Nimrod) **Proton Linear Accelerator**
Electrostatic Generator **Spiral Ridge Cyclotron** **Theoretical Physics**

DUTIES:

The work includes research into the production of intense beams of high energy particles; focusing, analysis and separation of these beams; use of bubble chamber, counter arrays and other detecting systems.

Besides the development work on Nimrod, the Proton Linear Accelerator, and design work on electrostatic generators and spiral ridge cyclotrons, there will be opportunities for research into new types of accelerators.

There are also vacancies for mathematical physicists in this work, and for programme development on an ORION computer.

CONDITIONS:

Permanent appointments will be made to the Scientific Officer class at salaries in the scales:

Scientific Officer £790—£1,310
Senior Scientific Officer £1,440—£1,770
according to qualifications and experience.

These appointments will be pensionable under the U.K.A.E.A. Non Industrial Superannuation Scheme.

QUALIFICATIONS AND EXPERIENCE:

Applicants should possess a good University Honours degree. It will be an advantage to have had some research experience in one of the following:

(i) Production and insulation of high voltages

(ii) production, focusing and measurement of ion or electron beams

(iii) electronic circuits

(iv) high power radio frequency apparatus

(v) low temperature equipment

(vi) high vacuum techniques

(vii) computational techniques, electromagnetic theory, microwaves, particle dynamics, or nuclear theory.

Certain of the posts are for Fixed Term appointments for periods up to five years. These will carry F.S.S.U. benefits. The salaries of these posts will be within one or other of the following ranges: £790–£1,310, £1,440–£1,770, and (exceptionally) £1,840–£2,590, according to qualifications and experience. There will be possibilities of range to range advancement during the period of service.

Applications, quoting the names of two professional referees and giving brief details of career, should be addressed to the Secretary,

RUTHERFORD HIGH ENERGY LABORATORY,
Harwell, Didcot, Berks.,
from whom further details may be obtained.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

PHYSICS DEPARTMENT

Applications are invited for the following posts in the photoelectronics section: Lecturer. Salary in range £1,050 by £50 to £1,400 by £75 to £1,550 (bar) by £75 to £1,850 per annum, plus £60 per annum London allowance and family allowance of £50 per child per annum. F.S.S.U. membership. Duties include teaching general physics and special advanced course, research in application of photoelectronics to nuclear physics, astronomy, space research, etc. Research Assistant (Academic) to assist in research in the fields of vacuum physics and photoelectronics. A good degree essential and some research experience preferable. Salary in range £700 to £1,100 per annum, dpending upon qualifications, plus family allowance. F.S.S.U. membership.

Apply, with full personal and academic details and names of two referees, to Professor J. D. McGee, Physics Department, Imperial College of Science and Technology, London, S.W.7.

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

BRUNEL COLLEGE OF TECHNOLOGY

Woodlands Avenue, Acton, W.3

Principal: Dr. J. Topping, M.Sc., D.I.C., F.Inst.P.

HEAD OF DEPARTMENT OF BIOLOGY

Applications are invited for the appointment of Head of the Department of Biology to commence on September 1, 1961, or as soon after as possible. Applicants should hold a good honours degree in biology and have appropriate teaching, research or industrial experience. The post is a new one, the work in biology having expanded considerably. There is a Diploma in Technology course and some postgraduate work. The Head of Department will be responsible for the further development of postgraduate courses and research. There is at present a full-time staff of eight, including a Principal Lecturer. The grade of the department is IV, salary scale £1,988 to £2,151 per annum.

Application forms and further particulars may be obtained from the Principal, to whom completed applications should be returned within 14 days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
Chief Education Officer.

CHEMICAL INSPECTORATE (WAR Office). Woolwich seeks two Assistants (female) for technical information and library work in the chemical field (simple searching, abstracting, compiling of records, assisting in library). Reading knowledge of at least one foreign language desirable. Qualifications: G.C.E. (A) chemistry and physics (or mathematics) and three "O" level subjects including English and Mathematics, or H.N.C. chemistry. Associateship of Institute of Information Scientists an advantage. Salary: £458 (at 18) to £983 (maximum) plus £20 to £40. Promotion prospects; day release for study.—Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting ref. F.315/1A.

SENIOR PRINCIPAL SCIENTIFIC Officer: Department of Scientific and Industrial Research. Pensionable post at Warren Spring Laboratory, Stevenage, Herts, for man or woman to lead research in chemical engineering and process development. Qualifications: normally first- or second-class honours degree in chemistry, physics, or chemical engineering; or high professional attainment. Research experience in the field of chemical engineering together with a sound knowledge of basic principles and theory, and an interest in basic research work essential. Works experience desirable. Salary scale £2,600 to £2,950 (subject to review). Starting salary may be above minimum.—Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting S/5321/61. Closing date July 13, 1961.

BUILDING RESEARCH STATION (D.S.I.R.), Garston, Watford, Herts, requires Scientific/Senior Scientific Officers to apply Operational Research and Statistical techniques to research problems concerning the efficiency and economy of the planning, design and construction of buildings. Qualifications: First- or second-class honours in mathematics, science or civil engineering. For Senior Scientific Officers, at least three years' postgraduate experience, some knowledge of operational research or statistical techniques and minimum age 26. Interim salary ranges Scientific Officer, £717 to £1,186, Senior Scientific Officer, £1,302 to £1,604.—Applications to the above address, quoting BRS.28XW. Closing date June 26, 1961.

UNIVERSITY OF ABERDEEN

DEPARTMENT OF NATURAL HISTORY

Applications invited for LECTURER IN ZOOLOGY as from October 1, 1961.

Salary on scale £1,050 to £1,850 with F.S.S.U., child allowance and removal allowance, and with placing according to qualifications and experience.

Further particulars may be obtained from The Secretary, The University, Aberdeen, with whom applications (eight copies) should be lodged not later than July 6, 1961.

BOTANIST OR AGRONOMIST FOR SERVICE IN MALAYA

The research organization of a major group of plantation companies operating in Malaya has a vacancy for a Botanist or Agronomist to take charge of a well-established oil palm research unit and in addition to undertake certain responsibilities relating to research in respect of rubber cultivation.

Applications are invited from those having a good honours degree in Botany or Agricultural Science with postgraduate training in Plant Breeding and/or Crop Physiology, followed by several years practical experience which should include direct charge of field experiments.

The initial salary and commission offered for this appointment will be at least £2,600 per annum plus allowances, free accommodation, passages and provident fund.

Applications, giving full details of qualifications, experience, age, etc., should be sent to Box F.839, c/o Streets, 110 Old Broad Street, London, E.C.2.

SIERRA LEONE

AGRICULTURAL CHEMIST

To advise the Director of Agriculture on specific problems and for investigational studies in the field including the laying out of field trials and their statistical analysis and interpretation. Candidates (male) must have a good honours degree in agricultural chemistry with some postgraduate experience preferably in the tropics. Appointment is on contract/gratuity terms for two tours of service in the first instance with emoluments in scale £1,039 to £1,924. Gratuity 15 per cent of aggregate emoluments. Free passages on appointment and leave for officer, wife and up to three dependent children under 18 years of age. Children's allowances. Furnished accommodation, usually available, at moderate rental. Generous leave.

Apply, stating name in full and giving brief details of qualifications and experience, to the Sierra Leone Recruiting Agency, Room 756, Sanctuary Buildings, Great Smith Street, London, S.W.1. Quoting reference No. BCD.63/15/04/C1.

UNIVERSITY OF ABERDEEN

Applications are invited for a Lectureship in Medical Physics in the Department of Natural Philosophy. Duties include teaching and research, but are primarily to secure implementation of the Universities' Code of Practice for control of radiation hazards throughout the University. Experience in a hospital physics department would be of advantage. Salary on scale £1,050 to £1,850 with F.S.S.U., child allowance and removal allowance.

Further particulars may be obtained from the Secretary, the University, Aberdeen, with whom applications (eight copies), should be lodged not later than July 6, 1961.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications are invited for the post of Demonstrator in Organic Chemistry. The Demonstrator would be expected to engage in research work, normally for higher degree. The appointment is tenable from September 1, 1961. Remuneration £620 per annum. The appointment is renewable annually. Usual tenure is for three years.

Applications should reach the Registrar, the College, Keele, Staffs, from whom further particulars and application forms may be obtained, not later than June 14, 1961.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY LONDON

ST. JOHN STREET, LONDON, E.C.1

DEPARTMENT OF PURE AND APPLIED CHEMISTRY

Applications are invited for Research Studentships available from September, 1961, from those holding or anticipating to have a good honours degree in chemistry, Grad.R.I.C., or Dip.Tech. in chemistry. Research topics will be selected from the following fields: the chemistry and origin of coal tar constituents; low temperature carbonization studies; physico-chemical studies, including electro-chemistry, surface chemistry, and states of aggregation in solution. The work will be suitable for studies leading to a postgraduate degree or equivalent. Each studentship will carry a stipend of £400 to £500, which may be supplemented by fees from teaching.

Applications, giving full details, including the names of referees, should be sent to the Head of the Chemistry Department as soon as possible.

DEPARTMENT OF AGRICULTURE

TANGANYIKA

BOTANIST

For Research into the improvement of varieties of crop plants to increase yield and resistance to diseases or pests. Candidates (male) must have a good honours degree in botany or agricultural botany and not less than two years postgraduate experience or training. Experience in plant breeding techniques is essential. Appointment on contract/gratuity terms for one or two tours of service of 21/27 months. Emoluments in range £1,266 to £2,448. Entry point determined by qualifications and experience. Gratuity 25 per cent of substantive emoluments. Generous education allowances. Free passages. Generous leave. Furnished accommodation, usually available, at low rental.

Apply, stating full name and giving brief details of qualifications and experience, to Director of Recruitment, Colonial Office, London, S.W.1. Quote BCD63/8/01/C1.

PHARMACOLOGIST

Science or medical graduate with research experience in pharmacology of physiology required in the Department of Pharmacology of our Research Laboratories. Ph.D. an advantage. New laboratories in beautiful countryside with easy access to London.

Apply, stating age, qualifications, experience and publications, to the Research Director, Miles Laboratories Ltd., Stoke Court, Stoke Poges, Bucks.

UNIVERSITY OF WESTERN AUSTRALIA

SENIOR LECTURESHIP IN MATHEMATICS

Applications are invited for appointment to the above-named position in the Department of Mathematics. The Department is responsible for teaching and research in pure mathematics, applied mathematics and mathematical statistics and the appointee may be a specialist in any branch of these three fields of mathematics. The salary range for the position is £A.2,450 by £A.100 to £A.2,950 per annum with superannuation similar to F.S.S.U.

It is important that intending applicants obtain details of the procedure to be followed in applying for the post and a copy of the conditions of appointment before submitting their applications. This information is available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on July 31, 1961.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

Applications are invited for the following posts tenable for five years from October 1, 1961, under a grant from the United States National Institutes of Health, for work on the flow and the coagulation of blood. 1. Principal Scientific Officer, with training in physiology and/or biochemistry, and preferably also in Physics. Experience in work on blood an advantage. Salary within range £1,666 to £2,418; F.S.S.U. 2. Assistant Experimental Officer preferably with pass degree or equivalent and experience in biological work. Salary range £450 10s. to £983.

Further particulars from the Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 61/18 for post 1 or 61/19 for post 2.

UNIVERSITY OF MANCHESTER

Applications are invited for two posts at the grades of Lecturer and Assistant Lecturer in Nuclear Engineering. Candidates should be graduates in engineering or physics; experience of experimental reactor control and instrumentation or heat transfer would be an advantage. The successful candidates will take part in teaching and research in the Nuclear Engineering Laboratory. University regulations permit teaching staff to read for the degrees of M.Sc. and Ph.D. Applications will also be considered from engineers and physicists who would be interested in a temporary appointment of two or more years. The salary scales are as follows: Lecturer, £1,050 to £1,850 per annum; Assistant Lecturer, £800 to £950 per annum. Membership of the F.S.S.U. and children's allowance scheme. Initial salary at the grade of Lecturer according to qualifications and experience.

Applications should be sent not later than June 24, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained. Applications by airmail letter in the first instance will be considered from overseas candidates.

ROYAL COLLEGE OF ADVANCED TECHNOLOGY

SALFORD

DEPARTMENT OF MATHEMATICS

Applications are invited for Research Demonstratorships and Research Studentships in the Department of Mathematics. Successful applicants will work under the supervision of Dr. R. A. Sack in Statistical Mechanics, or Dr. J. S. Lowndes in Applications of Integral Transforms, or Dr. F. Walkden in Supersonic Flow Fields, although other subjects will also be considered. Applicants should be suitably qualified and desire to carry out research either for a higher degree or for the Fellowship of this College or for Membership of the College of Technologists (M.C.T.). Demonstratorships carry an award of £350 per annum and are renewable annually. Studentships are renewable annually up to a maximum of three years, and carry an award of £500 rising to £600 per annum; the commencing point may be above the minimum.

Applications should be sent to the Registrar, Royal College of Advanced Technology, Salford 5, Lancs, by June 20, 1961.

AGRICULTURAL RESEARCH COUNCIL

Applications are invited for the following posts at the Council's Poultry Research Centre in Edinburgh, which is concerned with fundamental investigations into the biology of the fowl: Physiology: Two posts in the Principal Scientific Officer/Senior Principal Scientific Officer range, one to be concerned with endocrinology. Mathematics: One post in the Senior Scientific Officer range to be concerned with breeding methods and to give statistical advice in other investigations. These appointments will supplement existing research staff in genetics, biochemistry, pathology and behaviour. Salaries are: Senior Principal Scientific Officer, £2,650 to £3,000; Principal Scientific Officer, £1,716 to £2,418; Senior Scientific Officer, £1,342 to £1,654. Superannuation in F.S.S.U.

Applications should be sent to the Secretary, the Poultry Research Centre, King's Buildings, West Mains Road, Edinburgh, 9.

SURREY EDUCATION COMMITTEE

KINGSTON TECHNICAL COLLEGE

FASSETT ROAD, KINGSTON-UPON-THAMES

Required, Research Assistant in Ultrasonics in Department of Physics and Mathematics. The work will involve investigation of physical and chemical behaviour of liquid mixtures using ultrasonics. Applicants should possess qualifications satisfying University of London entry requirements for higher degrees. An interest in electronics an advantage. The salary will be approximately £650 and person appointed will be expected to undertake six hours of laboratory demonstration per week.

Further information and application form from Principal.

JUNIOR COMPUTING ASSISTANT Required for computational work in connection with a two-year research project on a D.S.I.R. Grant. Candidates with "A" level in mathematics preferred. Starting salary on scale £550 by £20 to £610 per annum, according to age and experience.—Send full particulars to the Assistant Secretary, Birkbeck College (University of London), Malet Street, W.C.1.

UNIVERSITY OF QUEENSLAND

SENIOR LECTURER IN PHYSIOLOGY

Applications are invited for the abovementioned position. Applicants should be graduates in science, medicine or veterinary science, preferably with doctoral qualifications and a sound experience in neurophysiology. Salary range £A.2,520 by £A.70 to £A.2,870 per annum. The successful applicant will enjoy the privileges of an F.S.S.U. type superannuation scheme, study leave, travel grants and other benefits available to the academic staff.

Further particulars and application forms are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on July 30, 1961.

JENSON & NICHOLSON LTD.

require a

SENIOR CHEMIST

FOR THEIR WOOD FINISHES DEVELOPMENT LABORATORY

with wide experience in the field of development and application of modern wood finishes, both clear and pigmented, including polyesters, polyurethanes, nitrocellulose and acid catalysed materials. Familiarity with electrostatic and curtain coating methods and with current practice in industry is essential. Salary commensurate with the wide experience required.

Applications, giving details of age, qualifications, experience and appointments held, quoting Ref. B.100, should be addressed to the **Personnel Manager, Jenson & Nicholson Ltd., Carpenters Road, Stratford, London E.15.**

WESTFIELD COLLEGE

(UNIVERSITY OF LONDON)

DEPARTMENT OF ZOOLOGY

Applications are invited for a Postdoctoral Fellowship (stipend £1,050 a year plus £60 London allowance) tenable for three years to undertake research on the distribution of Cephalochordata in relation to ocean currents in collaboration with Professor J. E. Webb. The appointment will date from October 1, 1961, and will carry benefit of superannuation (F.S.S.U.).

Further particulars may be obtained from the Secretary to Council, Westfield College, Hampstead, London, N.W.3, to whom applications (five copies), stating age, qualifications and experience, together with the names of three referees, should be submitted by Monday, July 3.

THE AGRICULTURAL RESEARCH Council invite applications for the following posts at their Institute of Animal Physiology: (a) Scientific Officer or Senior Scientific Officer for research on various aspects of mineral metabolism in ruminants. (b) Scientific Officer for research on physiology and biochemistry of milk secretion. Good second-class honours degree essential; a veterinary qualification would be a recommendation for the first of these posts. Salary: Scientific Officer £717 to £1,222; Senior Scientific Officer £1,302 to £1,654, according to experience. F.S.S.U.—Applications, with names of three referees, to the Secretary of the Institute, Babraham, Cambridge, within four weeks.

ROYAL NORTHERN HOSPITAL REQUIRES Technical Officer in Radiotherapy. Some knowledge of physics essential. Opportunity of gaining further experience in other departments. Salary £710 to £905 per annum plus London weighting (i.e., Senior Technician rate pending publication of separate scale). Whitley Council conditions.—Apply Hospital Secretary, Royal Northern Hospital, Holloway Road, N.7.

UNIVERSITY COLLEGE OF SWANSEA

DEPARTMENT OF GEOLOGY

Applications are invited for the following posts: Research Demonstrator. Applicants should be graduates in Geology and will be expected to engage in research. Salary £700 per annum, together with F.S.S.U. benefits and family allowances. Research Assistant. Applicants should be graduates in geology or chemistry or should graduate this year. The person appointed will assist the Professor in a study of the structure and composition of fossil and recent shells. Salary in the range £500 to £650 per annum.

Further particulars can be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications (six copies), must be received not later than Saturday, June 17, 1961.

ST. THOMAS'S HOSPITAL MEDICAL SCHOOL

Applications are invited for the post of Assistant Lecturer in the Department of Biochemistry. The post will be tenable from October 1, 1961. Commencing salary according to qualifications and experience, in the scale £950 to £1,150 per annum plus London allowance of £60. Membership of the F.S.S.U. and children's allowance scheme.

Applications, giving details of qualifications and the names of two referees, should be submitted by July 26, 1961, to the Dean, St. Thomas's Hospital Medical School, London, S.E.1, from whom further information may be obtained.

ROYAL VETERINARY COLLEGE

(UNIVERSITY OF LONDON)

Applications are invited for appointment as Assistant Lecturer in the Department of Veterinary Pathology, tenable at the College's field station near Potters Bar, Middlesex. Candidates should be veterinary surgeons or possess some other suitable qualification. Salary £800 by £50 to £950 per annum plus £60 per annum London allowance. Initial salary within the scale according to experience and qualifications. Superannuation benefits and children's allowances.

Application forms, obtainable from the Secretary, Royal Veterinary College, Royal College Street, London, N.W.1, should be returned not later than July 1, 1961.

HIGH DUTY ALLOYS LIMITED

RESEARCH DIVISION

SLOUGH, BUCKS

Physicist or Physical Metallurgist required for fundamental research on the phenomena associated with fatigue and creep of light alloys. Candidates should have an honours degree and preferably some experience of university research and be under 30 years of age. The work will be in a modern and very well equipped laboratory and encouragement is given for the publication of results. A generous salary, depending on qualifications and experience, is available and there is also a pension scheme in operation.

All applications will be treated in the strictest confidence. Please write, giving full details, to the Chief Personnel Officer, at the above address.

ESSEX COLLEGE

ASSUMPTION UNIVERSITY OF WINDSOR

WINDSOR, ONTARIO, CANADA

The Department of Physics invites applications for the following appointments: two Experimental Physicists, one Theoretical Physicist. The successful applicants will be expected to instruct undergraduate and graduate students and devote a part of their time to research. Preference will be given to candidates with interests in low energy nuclear physics, solid state physics, or molecular spectroscopy. The rank and salary will depend upon qualifications and experience, but the salary will not be less than $7,000 at Ph.D. level.

Inquiries should be addressed to the Chairman, Department of Physics, Assumption University of Windsor.

THE MEDICAL RESEARCH COUNCIL requires a Research Assistant with a good honours degree in biochemistry to study the factors influencing the renal excretion of calcium in man. The appointment is for three years in the first instance, and opportunities are available to register for a higher degree. Starting salary within the range £750 to £850 per annum.—Applications, with names of two referees, to Dr. A. Hodgkinson, Metabolic Disturbances in Surgery Research Unit, The General Infirmary, Leeds, 1.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications are invited for the post of Senior Lecturer/Lecturer in Mathematics. Applicants should be qualified in applied mathematics. The appointment will start from October 1, 1961, or as soon thereafter as can be arranged. The salary which will be not less than £1,550 per annum, will be in the scale £1,650 by £75 to £2,325 (Senior Lecturers), £1,050 by £50 to £1,400 by £75 to £1,850 (Lecturers), with F.S.S.U. and children's allowances.

Applications should reach the Registrar, the College, Keele, Staffs, from whom further particulars and application forms may be obtained, not later than June 17, 1961.

UNIVERSITY OF NOTTINGHAM

RESEARCH ASSISTANT IN AGRICULTURAL BOTANY

Applications are invited for the above appointment in the Department of Agricultural Sciences at the School of Agriculture, Sutton Bonnington, to carry out investigations on the growth of sugar beet. The appointment is for three years from September 1, 1961, salary £400 per annum. Applications will be considered from honours graduates (including prospective graduates this summer) in botany or agricultural botany. The successful candidate will be expected to read for a higher degree.

Conditions of appointment and form of application, to be returned by June 30, from the Registrar, the University, Nottingham.

BATTERSEA COLLEGE OF TECHNOLOGY

(A College of Advanced Technology)

LECTURER IN THEORETICAL SOLID STATE PHYSICS

Applications are invited for the post of Lecturer in Theoretical Physics of the Solid State in the Department of Physics. Salary scale: £1,408 or £1,421 to £1,601.

Applications should be sent to the Clerk to the Governing Body, Battersea College of Technology, London, S.W.11, from whom further particulars can be obtained. Closing date for applications is June 16.

BATTERSEA COLLEGE OF TECHNOLOGY

LONDON, S.W.11

Applications are invited from candidates with an honours degree for the post of Assistant Lecturer in the Department of Electrical Engineering. Research facilities are available and Lecturers are encouraged to work for higher degrees. Salary within the scale £950 to £1,486 per annum less statutory deductions.

Further particulars from the Clerk to the Governing Body to whom applications should be sent as soon as possible.

UNIVERSITY OF SHEFFIELD

Applications are invited for the post of Lecturer in Metallurgy to begin duties as soon as possible. Ph.D., or equivalent experience in metallurgy is desirable, or in pure science if interests and experience are related to metals. Initial salary according to qualifications and experience on the scale £1,050 by £50 to £1,400 by £75 to £1,850, with F.S.S.U. provision and family allowance. A grant towards removal expenses will be made.

Further particulars may be obtained from the Registrar, to whom applications (four copies), should be sent by July 1, 1961.

UNIVERSITY COLLEGE OF WALES

ABERYSTWYTH

Applications are invited for the post of Assistant Lecturer in the Department of Geology to commence duties on October 1, 1961. Qualifications in sedimentology and an interest in Recent sediments will be an advantage.

Applications should be sent not later than June 25, 1961, to the Registrar, from whom further particulars and forms of application can be obtained.

READING TECHNICAL COLLEGE

Grade B Assistant Teacher required for Science Department to teach Physics in O.N.C. Applied Physics and Chemistry courses and to G.C.E. "O" and "A" levels. Basic salary £700 to £1,150 with additions for qualifications and training. Commencing salary according to experience.

Further particulars and application forms obtainable from the Principal, Reading Technical College, King's Road, Reading.

UNIVERSITY OF READING

Applications are invited for a Lectureship or Assistant Lectureship in the Department of Agricultural Botany from botanists with special experience in the taxonomy, morphology or genetics of horticultural plants.

Further particulars may be obtained from the Registrar (Room 22, O.R.B.), the University, Reading, by whom applications must be received not later than July 3, 1961.

HISTOLOGIST

We have a vacancy for a graduate in pharmacy or science in our Surgical Research Unit in Kent for histological work on *in vivo* absorption of sutures. Five-day week and contributory Superannuation Scheme in operation. Salary according to qualifications and experience.

Apply to Technical Director, Ethicon Ltd., Bankhead Avenue, Edinburgh 11.

UNIVERSITY OF READING

Applications are invited from persons with special qualifications in pure mathematics for a Lectureship in Mathematics (Grade I or II). The appointment will date from September 30, 1961, or as soon thereafter as can be arranged.

Further particulars may be obtained from the Registrar (Room 22 O.R.B.), the University, Reading, by whom applications must be received not later than June 21, 1961.

GLASS-MINDED ENGINEER REquired with commercial knowledge. Able to follow projects in Chemical and Pharmaceutical Industries. Permanent and progressive position.—Applicants should submit details of education and career to date to Box 966, T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications are invited from Demonstrators and for a Curator, in the Department of Geology, tenable from September 1, 1961. Remuneration for both types of post £620 per annum.

Applications should reach the Registrar, the College, Keele, Staffs, from whom application forms and further particulars may be obtained, not later than June 30, 1961.

ASSISTANT EXPERIMENTAL OFFICER, for work on biochemical problems associated with the diseases of farm animals and the fundamental study of protein and nucleic acid biosynthesis. Salary on scale £740 (at age 25) to £983 per annum. Superannuation. Hostel accommodation available if required.—Applications, with the names of three referees, to Secretary, Agricultural Research Council, Field Station, Compton, near Newbury, Berks.

MEDICAL RESEARCH. APPLICATIONS are invited from Scientific Officers, probationary or post probationary grade (zoology, biology and chemistry) or Senior Technician II (N.H.S. salaries and scales) required for a research project into general and biological aspects of heart disease. Opportunity will be given for the preparation of a Ph.D. or I.M.L.T. thesis.—Further information from the Senior Pathologist, Central Laboratory, Milton Road, Portsmouth.

APPLICATIONS ARE INVITED FOR THE position of Assistant Professor of Biology with specialization in Limnobiology. Ph.D. standing or its equivalent from a recognized University is essential. Salary will be in the range $7,000 to $8,500, depending upon qualifications and experience. Appointment dates from July 1, 1962. Duties at the University commence not later than September 1, 1962, and include undergraduate teaching in general biology and a programme of research and graduate teaching in Limnobiology. Facilities in this field are excellent.—Applications, including curriculum vitae, names of referees, and a recent photograph, should be addressed to Head of Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

RESEARCH ASSISTANT WANTED AT Stoke Mandeville Hospital to help with current research on an immunological project connected with Rheumatoid Arthritis. The person appointed would work directly with the Pathologist undertaking the research. Salary £750 to £1,000 per annum according to qualifications.—Inquiries and applications giving details of experience and the names of two referees to the Pathologist Stoke Mandeville Hospital, Aylesbury, Bucks.

NORTHERN POLYTECHNIC

HOLLOWAY, LONDON, N.7

The Governing Body invites immediate applications for appointment as Lecturer in Mathematics. Applicants should possess a good honours degree in mathematics and be able to lecture up to the standard of the B.Sc. Special Degree. The successful candidate will be encouraged to engage in research. Salary scale: £1,370 by £35 to £1,510 by £40 to £1,550 plus London allowance.

Apply for form of application and further particulars to the Clerk to the Governors.

R. H. CURRELL, F.C.A.,
Clerk.

UNIVERSITY OF LIVERPOOL

Applications are invited for posts of Lecturer or Assistant Lecturer in the Department of Physiology at an initial salary within the range £1,050 to £1,450 per annum for a medically qualified candidate or within the range £800 to £1,475 per annum for a candidate having a dental or veterinary qualification or a science degree, according to age, qualifications and experience.

Applications, quoting Reference CV/N, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than June 23, 1961, by the Registrar, from whom further particulars may be obtained.

TEMPORARY EMPLOYMENT OF GEOLOGISTS

The Minister for Industry and Commerce is prepared to engage graduate Geologists for temporary duties during the summer months of 1961. Geologists applying should have had two seasons' field experience in Ireland. Full details may be obtained from the Secretary, Department of Industry and Commerce, Kildare Street, Dublin 2.

J. C. B. MacCARTHY,
Secretary.

UNIVERSITY OF WESTERN ONTARIO

LONDON, CANADA

Research Associate in radio physics, with M.Sc. or Ph.D., required for one year appointment. Salary commensurate with experience. Research includes instrumentation for study of turbulence in the lower atmosphere.

Applications to Professor D. R. Hay, Department of Physics.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Lecturer or Assistant Lecturer in the Department of Mathematics of the Faculty of Science. Candidates should have special qualifications in applied mathematics. Duties to commence on October 1, 1961, or as soon as possible thereafter. Salary scales per annum: Lecturer, £1,050 to £1,850, initial salary according to qualifications and experience; Assistant Lecturer, £800 to £950. Membership of F.S.S.U. and Children's Allowance Scheme.

Applications should be sent not later than June 19, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

WOOLWICH POLYTECHNIC

LONDON, S.E.18

Principal: Harold Heywood, D.Sc., Ph.D., A.C.G.I., Wh.Sch., M.I.Mech.E., M.I.Chem.E.

Applications invited for the following appointments in the Physics Department: Lecturer with an honours degree. A knowledge of either X-ray crystallography or of nuclear physics would be an advantage, but is not essential. There are facilities for research. Assistant Lecturer, Grade B, to teach in the first instance, up to General Certificate of Education, "A" level and Part I B.Sc. General Degree. The Physics Department is a large one with courses for the B.Sc. general degree and B.Sc. special degree in physics (internal) of the University of London. Salary: Lecturer, £1,370 by £35 to £1,550, Grade B within £828 to £1,426 according to qualifications and experience, both posts plus London allowance £38 to £51.

Particulars and application form from Clerk to Governors, to be returned by June 30, 1961.

TULLIS RUSSELL & CO. LTD., REQUIRE the services of a Laboratory Manager. Qualifications should include a good degree in science and considerable experience of laboratory organization, preferably but not necessarily, in the paper industry.—Applications to the Chief Chemist, Tullis Russell & Co. Ltd., Auchmuty & Rothes Paper Mills, Markinch, Fife.

UNIVERSITY COLLEGE OF SWANSEA

Applications are invited from suitably qualified candidates for the following posts in the Department of Physics: An Assistant Lectureship. A Lectureship. Salary scales: Lectureship, £1,050 by £50 to £1,400 by £75 to £1,850 per annum; Assistant Lectureship, £800 by £50 to £950 per annum. F.S.S.U. benefits and family allowances.

Further particulars can be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications (six copies), must be received by Saturday, July 1, 1961.

TRADE ANNOUNCEMENTS

UNWANTED MICROSCOPE — TURN IT into cash. We buy at top prices microscopes up to 50 years old, also barographs. Send or bring to the specialists. Wallace Heaton Ltd., 127 New Bond Street, London, W.1.

GRANTS & SCHOLARSHIPS

UNIVERSITY OF ABERDEEN

DEPARTMENT OF CHEMISTRY

RESEARCH STUDENTSHIP IN ELECTRODIALYSIS

Applications are invited from persons with an honours degree or equivalent qualification for the above studentship, which carries emoluments of £400 per annum (tax free) plus approved fees and some travelling allowance. The student will carry out research for a period of three years under the direction of Dr. P. Meares on fundamental aspects of the transport of ions in charged membranes using radioactive tracers. The work is supported by the A.E.R.E. Harwell, and the student will be expected to proceed to the degree of Ph.D. of Aberdeen University.

Applications, including the names of two referees, should be sent before July 15, 1961, to: Professor G. M. Burnett, Department of Chemistry, The University, Old Aberdeen.

UNIVERSITY OF LONDON KING'S COLLEGE

TUTORIAL STUDENTSHIPS

are offered from October 1, 1961, in the Departments of Biochemistry, Pharmacology and Physics. The value is £425 a year, with free tuition in King's College. Maximum tenure four years. Applicants must be graduates or about to graduate, and will be required to read for a higher degree and to give a limited amount of assistance by demonstrating.

Particulars and forms from the Registrar, King's College, Strand, W.C.2, whom completed applications should reach not later than June 19.

UNIVERSITY COLLEGE OF SWANSEA

POSTGRADUATE RESEARCH STUDENTSHIP IN CHEMICAL ENGINEERING

Applications are invited from persons expecting to graduate with honours in chemistry or chemical engineering for a postgraduate research studentship to study catalytic effects in gas/solid reactions. The work can form the basis for a Ph.D. degree. The Studentship will be tenable for three years in the Department of Chemical Engineering under the conditions that apply to D.S.I.R. Research Studentships.

Applications, including the name of one referee, must be received by the Registrar, University College, Singleton Park, Swansea, not later than June 30, 1961.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF MINING AND MINERALS ENGINEERING

Research Studentships, value £340 per annum (£270 if living at home) plus fees, are available for Chemists to carry out research either in the fundamental organic chemistry or the chemical utilization of coal. Candidates, who should possess a good honours degree, or who are to graduate in 1961, would be expected to supplicate for the degree of Ph.D.

Applications, naming two referees, should reach the Professor of Mining and Minerals Engineering, the University, Birmingham 15, as soon as possible and not later than July 1, 1961.

UNIVERSITY OF DUBLIN

TRINITY COLLEGE

RESEARCH STUDENT IN PHARMACOLOGY

Applications are invited for a Research Studentship in Pharmacology; duties to be taken up on September 21, 1961. Preference will be given to candidates whose interests lie in the field of endocrinology. The successful candidate will receive a stipend of £400 for the first year and £450 in a second year, and will normally be expected to read for a higher degree of the University of Dublin.

Applications (four copies), giving full details of academic career, etc., and the names and addresses of three referees, should reach the Registrar, Trinity College, Dublin 2, not later than June 26, 1961.

LECTURES AND COURSES

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, LONDON, S.W.3

DEPARTMENT OF CHEMISTRY

FULL-TIME COURSES LEADING TO GRADUATE MEMBERSHIP OF ROYAL INSTITUTE OF CHEMISTRY, COMMENCING SEPTEMBER, 1961

Applications are invited for a one-year course in preparation for Part II of the Graduateship examination. Candidates should have already passed or gained exemption from (i) Part I of the examination, and (ii) all ancillary subjects. Vacancies are strictly limited.

Apply to Head of Department.

GRESHAM COLLEGE, BASINGHALL Street, London, E.C.2. Tel. MONarch 2433. Four Lectures by Professor J. L. D'Silva, D.Sc., M.R.C.P. (Gresham Professor in Physic) on "Stress" on Monday to Thursday, June 12 to 15.—The Lectures are free and begin at 5.30 p.m.

SIMPLE TO USE
EASY TO CLEAN

Viscosities in the range 50 cP–2000 P can be measured without reference to calibration charts by
The TECHNE INDUSTRIAL VISCOMETER
Capable of immersion in a water bath, this viscometer has also a micro attachment for use with liquids of viscosities in the range 1–100 P; this requires only 0·7 millilitres of sample.

Accuracy	± 2%
Electrical Supply	200/250 V. 50 cycles AC 100/120 V. 50–60 cycles AC
Prices	Viscometer—£30 17s. 0d. Micro attachment—£7 10s. 0d.

TECHNE (CAMBRIDGE) LIMITED
Duxford · Cambridge · England Tel.: Sawston 2246

AP 207C

SOIL SAMPLERS

Mattson's Swedish Soil Samplers
AS ILLUSTRATED.

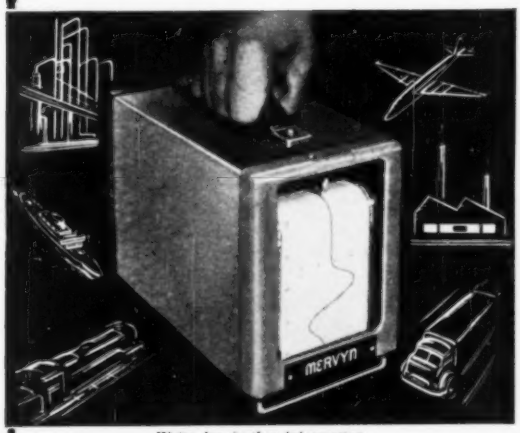
21" length	£4 10 0
36" length	£6 10 0

Other patterns include Walking-Stick Sampler, £4 15 0; and Hiller pattern Peat Samplers, with extension rods for greater depths.

Write for details "N."

J. H. STEWARD, LTD.
406 Strand, London, W.C.2
TEM. 1867 Estab. 1852

INSTRUMENT INSPIRATION



Write for further information, mentioning "Nature," to :

WOKING · SURREY · ENGLAND

Tel: Woking 5200-3

The Completely Battery-operated Portable

POTENTIOMETER RECORDER

Miniaturisation par Excellence!

For sheer versatility, there is nothing to approach this new MERVYN Instrument . . . its uses are legion both in the factory and in the field. It is the *only* Potentiometer Recorder that is both portable and self-contained—weighing just 17 lbs., complete with its own INTERNAL DRY BATTERY POWER SUPPLY.

* Internal Battery Power Supply has a life of 250 hours
* Low Drift Transistor Chopper operating at a frequency chosen to minimise 50-cycle interference
* Battery-driven motor for the combined Potentiometer and Writing Drive
* Transistorised amplifier and voltage reference from Zener Diode
* Inkless Recording using 7-day clock mechanism

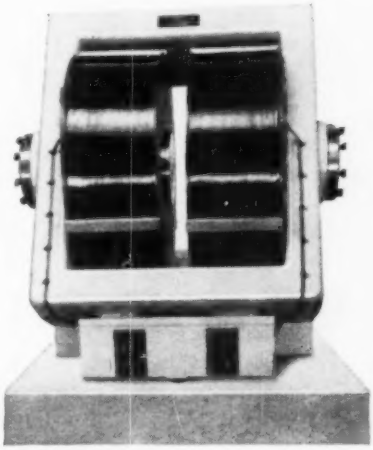
The ranges acceptable are from 0-5 mV up to 0-1 volt, by Interchangeable Range Cards

MERVYN INSTRUMENTS

FB17A

HOMOGENEITY

High and medium resolution n.m.r. require field homogeneities >1 in 10^6. This is only achieved by highest quality workmanship and attention to detail. The Newport 8" Electromagnet Type D with optically flat pole faces operates in the range of 0–12000 gauss. Maximum available field >15000 gauss. Rotating table available.



High Performance ELECTROMAGNETS

MAXIMUM
- Efficiency
- Field Strength
- Homogeneity
- Stability

MINIMUM
- Cost
- Size
- Weight
- Remanence

NEWPORT INSTRUMENTS

For full details write to :

NEWPORT INSTRUMENTS (Scientific & Mobile) LTD

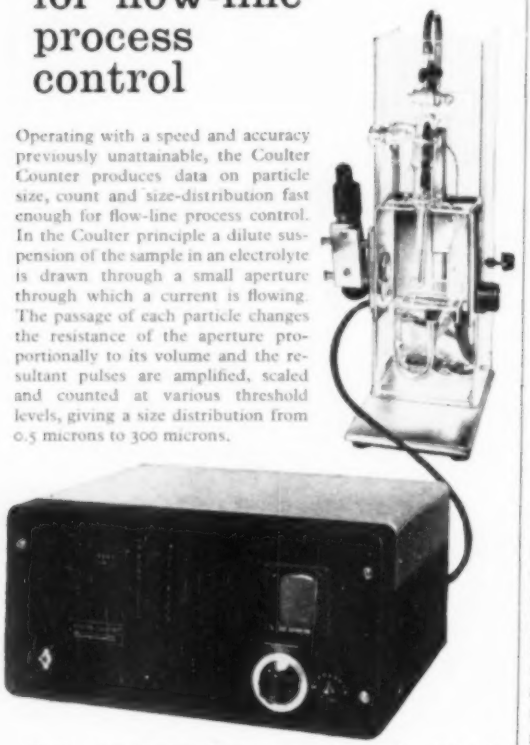
2 CRAWLEY ROAD · NEWPORT PAGNELL · BUCKS

Telephone: NEWPORT PAGNELL 401/2

COULTER COUNTER

for accurate particle-size distribution data fast enough for flow-line process control

Operating with a speed and accuracy previously unattainable, the Coulter Counter produces data on particle size, count and size-distribution fast enough for flow-line process control. In the Coulter principle a dilute suspension of the sample in an electrolyte is drawn through a small aperture through which a current is flowing. The passage of each particle changes the resistance of the aperture proportionally to its volume and the resultant pulses are amplified, scaled and counted at various threshold levels, giving a size distribution from 0.5 microns to 300 microns.

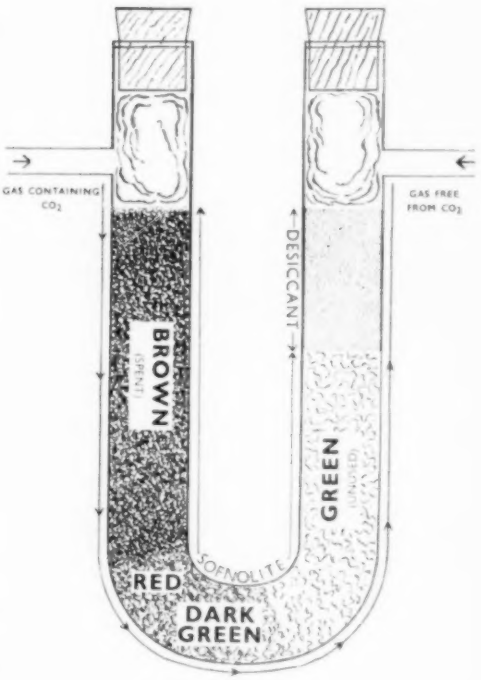


Over 1,500 Coulter Counters are already in service in industry and medicine. Full details and technical literature will be sent on request.

COULTER ELECTRONICS LTD
2-4 ASHWELL STREET,
ST. ALBANS, HERTFORDSHIRE
Telephone: ST. ALBANS 53402

SOFNOLITE

CO_2 ABSORPTION *PLUS* INDICATION



SOFNOLITE is a highly purified form of soda-lime, specially developed for gravimetric CO_2 analysis and contains a green/brown indicator. Being solid it can be packed in ordinary U-tubes, which are much easier to fill and weigh than, for example, potash bulbs. Another advantage is the distinct colour division between used and unused material along the tube. The end of absorption is clearly observable, when the division stops moving. One tube of SOFNOLITE can be used several times without re-charging until exhausted. Gravimetric accuracy is high—results in many cases are better than those obtainable with caustic potash; we shall be glad to send experimental figures. SOFNOLITE can also absorb other acid gases, such as SO_2 or HCl. Please send for full details of this convenient, accurate and inexpensive absorbent to:—

SOFNOL LTD
WESTCOMBE HILL · GREENWICH · LONDON, S.E.10
TAS/SL349

308 'ANALAR' Reagents

First in 1911 to publish a series of British Reagents Specifications, Hopkin & Williams Ltd., were one of the two companies who in 1934 introduced the now widely-accepted system of 'ANALAR' specifications*.

From the outset Hopkin & Williams have manufactured and tested reagents to these specifications with a meticulous care that has inspired confidence in 'ANALAR' throughout the world. From time to time more effective methods of purification permit the tightening of existing specifications, and new ones are added to meet the users' up-to-date requirements. At present no less than 308 'ANALAR' Laboratory Reagents, besides many other ranges of chemicals for special purposes, are available as part of the H. & W. service to research, analysis and industry.

*"'ANALAR' STANDARDS FOR LABORATORY CHEMICALS", 5th Revised Edition 1957, 21/- post free.

H&W TRADE MARK

CHEMICALS

for research, analysis and industry

HOPKIN & WILLIAMS LTD. CHADWELL HEATH, ESSEX, ENGLAND

Branches: London, Manchester, Glasgow *Agents throughout U.K. and all over the world*

TAS/HW.15

B.T.L. anhydric incubators

In addition to the well-known 'Bara' water-jacketed incubators, B.T.L. now offer anhydric incubators in two sizes with a range of 25°C–110°C, good thermal stability and an economical price. Identical cultures, chosen for their intractability, incubated both in these and in a water-jacketed type, have shown no difference in results. The incubators have three aluminium shelves locatable on eight runners, an inner door of toughened plate glass, and a B.T.L. bi-metallic temperature regulator with locking device and pilot light.

WE ARE EXHIBITING AT "ACHEMA"

Large Model **Cat. No. C 13/017** **£69-10-0**
Small Model **Cat. No. C 13/018** **£47-10-0**

Please send for full details

BTL complete laboratory service

BAIRD & TATLOCK (LONDON) LTD., CHADWELL HEATH, ESSEX, ENGLAND.

Branches in London, Manchester, Glasgow. *Agents throughout U.K. and all over the world.*

TAS/BT 73

Printed in Great Britain by FISHER, KNIGHT & CO., LTD., The Gainsborough Press, St. Albans, and published by MACMILLAN & CO., LIMITED, at St. Martin's Street, London, W.C.2, and ST. MARTIN'S PRESS, INC., 175 Fifth Avenue, New York 10, N.Y., U.S.A.—Saturday, June 10, 1961.